NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

REGULATION SCHEME FOR IMPROVED EFFICIENCY AND INNOVATION IN WIRELESS COMMUNICATIONS

by

John R. Kajmowicz

March 2009

Thesis Advisor:	Bert Lundy
Second Reader:	John Gibson

Approved for public release; distribution is unlimited.

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** March 2009	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE Regulation Scheme for Improved Innovation and Efficiency in Wireless Communications		**5. FUNDING NUMBERS**	
6. AUTHOR(S) LT John R. Kajmowicz, USN			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000		**8. PERFORMING ORGANIZATION REPORT NUMBER**	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A		**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited		**12b. DISTRIBUTION CODE**	

13. ABSTRACT (maximum 200 words)

Current FCC regulation of the electromagnetic spectrum hinders the growth of wireless communication technology and fails to make efficient use of an extremely valuable asset. Current policies have failed to keep pace with advancing technology and require a completely new allocation scheme in order to promote growth in the wireless communications industry. This paper proposes a new allocation scheme for spectrum regulation that promotes competition in the marketplace in order to make the most effective use of the physical medium and eliminates unnecessary barriers to entry into the market to promote innovation. Building upon fifty years of property-rights proposals for spectrum allocation, an understanding of the historical events that made regulation a necessity, and effects of liberalized policies in spectrum as well as other industries, led to the creation of an allocation scheme that takes full advantage of the competitive market and minimizes the detrimental effects from antiquated regulation policies. A spectrum lease scheme grants full flexibility of use to leaseholders, yet still maintain minimal governmental control to ensure interference protection.

14. SUBJECT TERMS Electromagnetic spectrum regulation, spectrum allocation, spectrum lease, wireless communication			**15. NUMBER OF PAGES** 123
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited.

REGULATION SCHEME FOR IMPROVED EFFICIENCY AND INNOVATION IN WIRELESS COMMUNICATIONS

John R. Kajmowicz
Lieutenant, United States Navy
B.S., United States Naval Academy, 2001

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE

from the

NAVAL POSTGRADUATE SCHOOL
March 2009

Author: John R. Kajmowicz

Approved by: Bert Lundy
Thesis Advisor

John Gibson
Second Reader

Peter Denning
Chairman, Department of Computer Science

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Current FCC regulation of the electromagnetic spectrum hinders the growth of wireless communication technology and fails to make efficient use of an extremely valuable asset. Current policies have failed to keep pace with advancing technology and require a completely new allocation scheme in order to promote growth in the wireless communications industry. This paper proposes a new allocation scheme for spectrum regulation that promotes competition in the marketplace in order to make the most effective use of the physical medium and eliminates unnecessary barriers to entry into the market to promote innovation. Building upon fifty years of property-rights proposals for spectrum allocation, an understanding of the historical events that made regulation a necessity, and effects of liberalized policies in spectrum as well as other industries, led to the creation of an allocation scheme that takes full advantage of the competitive market and minimizes the detrimental effects from antiquated regulation policies. A spectrum lease scheme grants full flexibility of use to leaseholders, yet still maintain minimal governmental control to ensure interference protection.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

First and foremost, I would like to express my heartfelt thanks to my beautiful wife, Beth, and my two amazing boys, Ryan and Jake. You guys keep me striving to be the best person that I can be. To my parents, thank you for setting such a great example for me to follow. Thank you Professor Lundy and Professor Gibson for all of your help. You both challenged me and greatly assisted me to get this done. Pete, Todd, Slack, Howie, Andy, Yannis and Paul, it was a great two years and you guys kept it fun. Pete, I'm sorry to disappoint you, but I was unable to squeeze the word swell into the text of my thesis.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

There is little doubt that the current regulation in wireless communications needs to be replaced with a more efficient system of allocation that promotes technology rather than hinders it. It is not a new idea. For fifty years, numerous people, with different backgrounds, have advocated implementation of a property-rights model for spectrum allocation. Each proposal may differ in the details of implementing a property-rights scheme, but there is little doubt that implementing a property-rights allocation model for spectrum allocation will result in a more competitive market and efficient use of the available spectrum.

The electromagnetic spectrum creates unique problems in wireless communications. Initial use of the medium for transmission by the government and private industry resulted in a chaotic mess that required the government to regulate in order to make effective use of the available medium.

The regulations have changed very little over the eighty years since their inception. Our current regulation structure struggles to keep up with technology and far too often hinders the growth of the wireless communications industry.

This paper draws upon the knowledge from decades of proposals, real world implementation of more liberal spectrum allocation schemes, and a model for successful deregulation to propose an allocation scheme of spectrum leases. The lease scheme will maximize competition in the market and eliminate the unnecessary barriers to entry into the marketplace for new technologies and competition. The proposal implements all the benefits of a property-rights scheme and includes an efficient administrative system to oversee allocation and dispute resolution. The scheme makes more efficient use of the spectrum and promotes innovation.

Chapters II through IV present background information for this proposal. In Chapter II, the physical properties of the electromagnetic spectrum and some of the difficulties of wireless communications are discussed, as well as the history behind the events leading to the current form of wireless regulation in the United States. Chapter III

talks about the current form of spectrum regulation in the United States and details of some of the unintended consequences of the current form of regulation. Chapter IV contains summaries of some of the leading proposals for adopting a new spectrum allocation scheme. The first part lays out four proposals that represent over fifty years of opinions on the matter. It also discusses the real world application of property-rights in Guatemala and El Salvador, as well as an analysis of the results as seen in the market. The final section of Chapter IV provides background information about the benefits of deregulation in other industries and lays out a blueprint for successful deregulation of future industries. Chapter V details the proposed spectrum lease scheme, the administrative requirements, and interference resolution process. Chapter VI illustrates the benefits of this proposed scheme versus the current regulations in the United States.

There is very little doubt that the current spectrum regulations in the United States hinder the pace of advancement in the wireless communication industry. Even the FCC acknowledges that they desire to implement a more efficient allocation scheme for spectrum and strive towards property-rights. There is apprehension to completely turn the electromagnetic spectrum over to the open market. This lease proposal satisfies all sides of the argument. By leasing the spectrum, the government maintains overall control of the spectrum but permits full flexibility to leaseholders in order to take advantage of competition in the marketplace to most efficiently allocate the spectrum.

II. THE ELECTROMAGNETIC SPECTRUM AND INITIAL REGULATION

The physical properties of electromagnetic energy must be understood in order to manage the allocation of spectrum. Electromagnetic waves, of different wavelengths, will exhibit different propagation characteristics under identical conditions; similarly, the environmental conditions cause identical frequencies to act differently. This chapter outlines some of the difficulties associated with the operating characteristics of the electromagnetic spectrum. It also describes the events leading up to the government implementation of strict regulations over the broadcast industry and rationale for the decision by Congress to impose regulation.

A. ELECTROMAGNETIC WAVE PROPAGATION

Real world propagation of electromagnetic waves is difficult to predict. Table 1 summarizes the characteristics of each spectrum band and current technologies employed.

Frequency Band	Designation	Common Applications
3 - 30 kHz	Very Low Frequency (VLF)	Submarine Communications
30 - 300 kHz	Low Frequency (LF)	Long Wave Radio
300 kHz - 3 MHz	Medium Frequency (MF)	Short/Medium Wave Radio
3 - 30 MHz	High Frequency (HF)	FM Radio
30 - 300 MHz	Very High Frequency (VHF)	Television
300 MHz - 3 GHz	Ultra High Frequency (UHF)	Television, Mobile Communication
3 - 30 GHz	Super High Frequency (SHF)	Satellite TV/Communications
30 - 300 GHz	Extremely High Frequency (EHF) – "millimeter wave"	Point-to-Point Microwave and Satellite Communications

Table 1. Spectrum Bands and Applications

Low frequency signals can be easily predicted and will travel between the Earth's surface and the Ionosphere. They are high power and low frequency transmissions that can propagate over long distances and penetrate water.

Waves in the frequency band, 300 kHz to 3 MHz travel in two paths: ground waves and sky waves. The propagation characteristics are affected by the time of day and weather.

The frequency band from 3 MHz to 30 MHz is considered the shortwave region. Electromagnetic waves in this frequency band are affected by atmospheric conditions and solar activity.

Very High Frequency (VHF) spectrum encompasses the frequencies from 30 MHz through 300 MHz. Technologies implemented in this frequency band consist of VHF television broadcast, FM radio, and mobile services. Penetration of the waves into buildings is minimal and the lower range spectrum in this band is affected by conditions in the atmosphere.

The frequency band from 300 MHz through 3 GHz is known as the Ultra-High Frequency (UHF) range. This is considered the most desirable band of frequencies. Propagation characteristics of UHF waves allow it to penetrate into and around buildings. Directional antennas can be used to focus all the transmission energy in one direction to minimize interference and maximize transmission area. UHF spectrum energy is not affected by changes in the climate. However, signals in this range are affected by refraction through the atmosphere, diffraction around the edges of objects, and reflections off of obstacles. The propagation of signals can only be predicted by statistical modeling since the effects of interference are not static.[1] Energy will spill over into adjacent frequencies. An early proponent of property-rights in spectrum noted that different bands of the spectrum had different propagation characteristics and may require a different set of rules.

> The propagation of radio waves is affected by the atmosphere, the ionosphere, the curved surface of the Earth, and even mountains, buildings, fields, deserts, and oceans. Since these effects vary widely

[1] Philip Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 580.

depending upon frequency, some ranges of frequencies may require different forms of property arrangements.[2]

1. Geographic Spillover

Radio waves propagate in a manner that is difficult to predict with certainty. The signals cannot be fenced in and will travel indefinitely through space. Reception of the signal is limited by the dissipation of the energy as the signal moves away from its point source and the interference and noise present at the receiver. The electromagnetic energy emitted does not recognize or obey arbitrary boundaries and react to the dynamic properties of our atmosphere.

The figures below show an example of how different electromagnetic energy propagates from predicted models and in reality. Figure 1 represents the predicted range of transmission of energy from a broadcast tower in Denver, CO.

[2] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1502.

Figure 1. Predicted Propagation Model[3]

The waves do not behave ideally. In reality they are affected by the atmosphere, geography, and manmade structures. Figure 2 illustrates the actual behavior of the transmitted waves from the same tower modeled above. The FCC initially established overly conservative geographic boundaries to eliminate the chance of interference with other emitting systems.

[3] Philip Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 585.

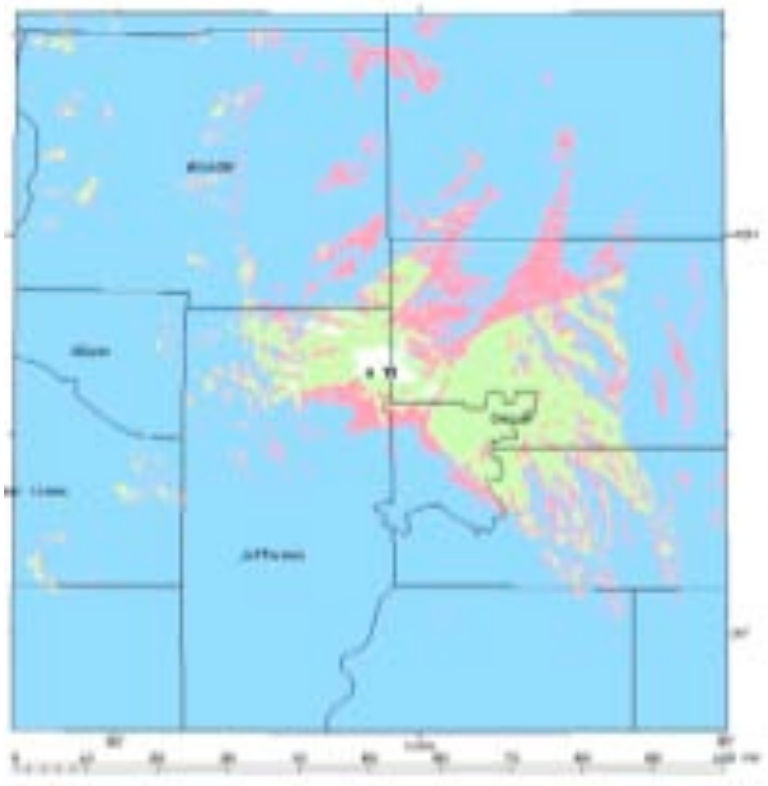

Figure 2. Actual Propagation Behavior[4]

2. Adjacent Channel Spillover

Interference in the adjacent channel results from transmissions of energy outside the prescribed bandwidth and inadequate filtering by receivers. Initial regulation by the FCC created large buffer zones between spectrum bands to eliminate the risk of interference from adjacent channels. Their regulations failed to keep pace with advances in transmitter and receiver performance that make more efficient use of the available electromagnetic spectrum.

[4] Philip Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 586.

B. PATH TO INITIAL REGULATION

1. Early Lobbying for Regulation

The first attempt to lobby Congress for spectrum regulation was made by the United States Navy in 1910. The Secretary of the Navy attempted to prove to Congress that broadcast conditions created by an independently operated radio station transmitting electromagnetic waves, as desired, would lead to a chaotic condition. This would hinder public business and possibly interfere with distress signals. Additionally, he pointed out that standards were lacking and behavior by the operators was unethical, by sending out false signals or false identification. He said, "It is not putting the case too strongly to state the situation is intolerable, and is continually growing worse."[5]

Congress passed the first Act regulating electromagnetic use of the airwaves on August 13, 1912. All operators were required to have a license, issued by the Secretary of Commerce, in order to operate. The license detailed the location, the authorized wavelengths, and the specific hours of permissible operation. Following the sinking of the *Titanic*, it required ships to carry equipment capable of emergency transmission.[6] An amateur spectrum band of wavelengths less than 200 meters was established, but wavelengths between 600 and 1,600 meters required a commercial license.[7]

In 1917, the Secretary of the Navy, Joseph Daniels, lobbied Congress for exclusive ownership of all wireless communication. He explained that radio was, "the only method of communication which must be dominated by one power to prevent interference… The question of interference does not come in at all in the matter of cables or telegraph but only in wireless."[8] Because of the unique nature of wireless communication, he believed that one government agency or corporation could only

---

[5] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 3.

[6] Bert Lundy. Telegraph, Telephone and Wireless: How Telecom Changed the World. Charleston, SC: Booksurge, 2008: 507.

[7] Coase: 3.

[8] Ibid.

accomplish effective regulation. The responsibility could not be shared. His attempts to lobby Congress for control of the spectrum failed.

2. Boom of the Broadcast Industry

In March 1920, Richard Sarnoff, the President of the Radio Corporation of America (RCA), wrote that, "It would seem reasonable to expect sales of $1,000,000 'Radio Music Boxes' at $75 each within a period of three years."[9] In March of 1922, there were 60 broadcasting stations in the United States. Six months later, there were 564.[10] "In the three year period, 1922-1924, RCA's sales of home radios were $83,500,000, slightly exceeding Sarnoff's prediction."[11]

3. Chaotic Regulation: 1922-1927

Herbert Hoover served as Secretary of Commerce from March 5, 1921 through August 21, 1928.[12] Hoover conducted annual radio conferences and consistently lobbied Congress for improved regulations. He was unsuccessful at getting an improved regulation framework passed into law so he regulated according to the powers granted in the Act of 1912. There were two lawsuits during the 1920s that effectively removed the authority of the Secretary of Commerce to regulate the airwaves: the Intercity Radio Company lawsuit and the Zenith Radio Corporation case.

In 1921, Secretary Hoover declined a license renewal request for the Intercity Radio Company. The company challenged the ruling in court. The court ruled that the Secretary had no authority to refuse licenses and therefore had no control over the

---

[9] Bert Lundy. Telegraph, Telephone and Wireless: How Telecom Changed the World. Charleston, SC: Booksurge, 2008: 498.

[10] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 4.

[11] Lundy: 498.

[12] "Secretaries." *The United States Department of Commerce*. 5 March 2009. 10 March 2009 <http://www.commerce.gov/About_Us/Secretaries/index.htm>.

number of stations established in the United States. The wording of the ruling implied that the Secretary of Commerce did not possess the authority to specify the wavelengths that a licensee could use.[13]

In 1925, Secretary Hoover issued extremely restrictive rights to the Denver, Colorado affiliate of the Zenith Radio Corporation. He issued a license that allowed the affiliate to transmit a wavelength of 332.4 meters, only between 10:00pm and midnight, and only on Thursdays when General Electric was not using the band.[14] Zenith violated the restrictive license and challenged the restrictions in court. In April 1926, a court ruled that, "the Act did not give the Secretary of Commerce power to make regulations and that he was required to issue a license subject only to the regulations of the Act itself."[15]

Secretary Hoover interpreted the results of both cases to be conflicting and requested the Attorney General rule on clarification. "The Secretary of Commerce was compelled to issue licenses to anyone who applied, and the licensees were then free to decide on the power of their station, its hours of operation, and the wavelength they would use."[16] The ruling led to complete chaos in broadcasting. Over 200 broadcasting stations were established in a nine-month period and Congress was forced to act.

C. THE BIRTH OF MODERN REGULATION

1. The Federal Radio Commission

The chaotic broadcast industry that resulted following the Attorney General ruling forced Congress to pass legislation to avoid interference between competing users of the spectrum. Both houses came to an agreement on a new communications regulation in

[13] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 5.

[14] Ibid.

[15] Ibid.

[16] Ibid.

December of 1926. The Act was signed in February of 1927 and established a new regulating body for wireless communications: the Federal Radio Commission.[17]

The Commission was granted total power to regulate all aspects of the wireless spectrum. It was given the authority to classify radio stations, prescribe the nature of service, assign wavelengths, determine power limits and locations of transmitters, regulate equipment use, and create a set of rules to eliminate interference. All broadcast license requests were to be made to the Federal Radio Commission.

The wording of the 1927 Act provided the Commission with broad power to regulate the wireless spectrum. The law permitted that the Commission,

> May prescribe as to the citizenship, character, and financial, technical, and other qualifications of the applicant to operate the station; the ownership and location of the proposed station and of stations, if any, with which it is proposed to communicate; the frequencies or wave lengths to be used; the hours of the day or other periods of time during which it is proposed to operate the station; the purposes for which the station is to be used, and such other information as it may require.[18]

The Commission took swift action to restore order in the communications industry. "One of the first actions which the new Radio Commission took was to reduce the number of stations broadcasting on the air. In 1928, 162 broadcasters were challenged to prove that their broadcasting rights should not be continued. The majority took their cases to court, but several went off the air."[19]

2. The Federal Communications Commission

The FCC was created by an act of Congress on June 19, 1934.[20] The powers of the Federal Radio Commission were absorbed by the newly formed FCC, which also

---

[17] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 5.

[18] Ibid., 6.

[19] Bert Lundy. *Telegraph, Telephone and Wireless: How Telecom Changed the World*. Charleston, SC: Booksurge, 2008: 508.

[20] Fritz Messere. "The FCC." *Museaum of Broadcast Communications*. 8 January 2009 <http://www.museum.tv/archives/etv/F/htmlF/federalcommu/ federalcommu.htm>.

became responsible for regulating the telephone and telegraph industries. The Telecommunications Act of 1934 allowed for the extensive regulation of the airwaves that continues today. "The Commission was given the broad latitude to establish a rapid, efficient, nation-wide, and world-wide wire and radio communication service."[21]

The FCC originally contained three divisions to handle broadcast, telephone, and telegraph. It merged responsibilities from the Federal Radio Commission, the Interstate Commerce Commission, and the Postmaster General. The FCC now regulates new technologies, including satellite, microwave, and private radio. Section 303 of the Act gave the FCC, "the power to classify stations and prescribe services, assign frequencies and power, approve equipment and mandate standards for levels of interference, make regulations for stations with network affiliations, prescribe qualifications for station owners and operators, levy fines and forfeitures, and issue cease and desist orders."[22]

Over the course of the FCC existence, there has been no consistent pattern of decision-making, which impacts their credibility to enforce fair regulation. Early on, decisions favored business over educational or community interests. They also have made decisions over the years that have been critical of corporations.

3. Modern View of FCC Regulation

Economist Ronald Coase rejected the belief that the FCC acts in the best interest of the public. He argued that the finiteness of spectrum should not be the reason to regulate. On the contrary, most scarce resources were allocated privately in the marketplace and that spectrum would be best allocated through the price mechanism in the marketplace.

Former FCC Chief Economist Thomas Hazlett asserts that the regulatory regime was put in place because of bad motives and not bad reasoning, as Coase reasoned. Lawmakers were aware of the property-rights model, but rejected it to protect their own self-interests. "Hazlett maintains that these lawmakers sought to place themselves at the

[21] Fritz Messere. "The FCC." *Museaum of Broadcast Communications*. 8 January 2009.

[22] Ibid.

'nexus of decision making in a brisk competitive rivalry for zero-priced frequency rights' and thus to provide themselves with 'a very well understood discretion over the life and death of lucrative and influential broadcasters.'"[23]

Two former students of Thomas Hazlett presented the most logical explanation behind the reasoning of Congress to implement strict regulations over the wireless communications industry. David Moss and Michael Fein contend that it was not flawed analysis or deceptive analysis that led to regulation, but fear of the power that broadcast ability would provide. "Given the (apparent) reality of a limited radio spectrum and the extraordinary political influence that the right to broadcast seemed to convey, federal lawmakers turned fiercely against a market solution."[24]

Politicians in the 1920s feared monopolization of the broadcast industry and the concentration of power in a small number of people. Unethical tactics used by broadcasters in the 1920s led the politicians to fear the possibility of an unregulated spectrum and the inability to regain control if the industry was left to the open market. Representative Luther A. Johnson summed up the political fear by saying, "There is no agency so fraught with possibilities for service of good or evil to the American people as the radio."[25]

The three arguments take different viewpoints on the reasons for Congress to enact the initial regulation of the wireless spectrum. Coase contends that it was flawed logic. Hazlett believes lawmakers framed the case deceptively in order to keep power, and Moss and Fein contend that there was legitimate fear of allowing free reign for broadcasters in the late 1920s. The three viewpoints present logical explanations for the government to enact spectrum regulation in 1927. However, the reasoning used to support regulation is no longer valid today.

Economically, spectrum regulations have created unnecessary obstacles for implementing new technology. Unlike in the 1920s, the electromagnetic spectrum can no

---

[23] Michael R. Fein and David A. Moss. "Radio Regulation Revisited: Coase, the FCC, and the Public Interest." *The Journal of Political History* 15.4 (2003): 396.

[24] Ibid., 391.

[25] Ibid., 401.

longer be looked at as a finite source for broadcasters. Alternative means for transmitting information, better transmitting and receiving technologies, and more efficient techniques that better utilize the available spectrum make it nearly impossible for a small number of people to concentrate resources in order to monopolize the political viewpoint that is transmitted to the people of the United States. There is no need to maintain the current regulative power over today's wireless communications industry.

D. CHAPTER CONCLUSION

The varying propagation characteristics of the electromagnetic spectrum provide unique challenges to the implementation of an effective management structure. Initial attempts by the wireless communications industry, with loosely implemented regulations, to make effective use of the airwaves resulted in chaos.

The response by the government was to enact firm regulations imposed by a powerful bureaucratic government agency. However, what resulted was the establishment of an orderly wireless communications industry. Over the years, issues with the FCC and their regulation decisions have led to calls for reform. The guidelines for the initial spectrum regulation remain today and the rapid growth of recent wireless technologies has exposed the need for modernization of the current spectrum regulations.

III. SPECTRUM REGULATION IN THE UNITED STATES

Due to the physical properties of the electromagnetic spectrum and history of the industry, regulation in wireless communication is much different than in other technologies. Regulation plays a much more important role. The resource is shared as everyone has access to the broadcast medium. In the 1920s, a lack of knowledge and coordination in the industry led to chaos, which led to the strict regulation that exists today. This chapter explains how spectrum is regulated today, identifies the FCC's future goals for spectrum regulation, and highlights some examples of the shortcomings of the current model of regulation.

A. SPECTRUM REGULATION AGENCIES

Three agencies regulate the spectrum. The International Telecommunications Union (ITU) implements international spectrum policies as a sanctioned organization of the United Nations since 1946.[26] The United States is a member. In the United States, responsibility for spectrum management is divided between two agencies: the FCC and the National Telecommunications and Information Administration (NTIA). The FCC handles regulation of the commercial wireless communications industry and the NTIA coordinates government use of the spectrum.

The ITU is a specialized treaty organization of the United Nations. The participants of the ITU meet in the World Radio Conference. Participation in the ITU by the United States is coordinated through the Department of State.[27] The FCC administers spectrum regulation for non-federal use of the wireless spectrum. This includes state and local governments, commercial wireless industry, private business and personal use. The NTIA operates under the Department of Commerce and administers all access to the

[26] "About ITU." *The International Telecommunications Union*. 19 March 2009. 19 March 2009 <http://www.itu.int/net/about/index.aspx>.

[27] Michael J. Marcus. "Wireless Communication Standards and Regulations." Presentation at IEEE Workshop, Phoenix, AZ. 2004.

wireless spectrum for federal use.[28] This includes the use of the spectrum by federal agencies such as the Department of Defense, the Federal Aviation Administration, and the Federal Bureau of Investigations.

B. FCC REGULATION

1. Regulations

Regulation and enforcement of FCC spectrum policies has traditionally been handled by the command-and-control structure of the FCC. The FCC makes the rules, enforces the rules, and adjudicates disputes. Prior to the early 1990s, an FCC panel decided who would be granted licenses to broadcast in the wireless spectrum. Currently, the FCC uses an auction scheme to distribute licenses to broadcast in the wireless spectrum. The FCC has all authority over radio use in the United States except for government use. All policies are available for review and available through a process of public notice and comment, which allows the public to view policies and make comment prior to the Commission instituting the policy.

The Office of Engineering and Technology (OET) handle all rules concerning the wireless spectrum within the FCC. The OET provides technical advice on spectrum issues and maintains the Frequency Allocation Table. Allocated frequency licenses, between 9 kHz and 275 GHz, are maintained within the OET.

The Frequency Allocation Table is a compilation of all allocations by the FCC. It lists all primary and secondary services within each allocated spectrum band. Secondary services operate in the same allocated bands as primary services allowing for more efficient use of allocated bands. A secondary licensee shall not cause harmful interference to primary services and receives no guarantee of protection from interference from primary license holders; however, they are protected from interference from other secondary licensees. The OET not only maintains the current allocation table of licensed frequencies but also maintains the history of tables and reports by the FCC.

[28] *FCC Radio Spectrum Home Page*. 27 February 2008. The Office of Engineering and Technology, The Federal Communications Commission.

2. Auctions

Since 1994, the FCC has used an auction scheme for allocating spectrum to new users. The Omnibus Budget Reconciliation Act of 1993 authorized the FCC to auction licenses to new bands of spectrum.[29] Any company or individual that is deemed eligible by the Commission can participate in the open auctions that are conducted over the Internet. The FCC believes that auctions provide the most efficient mechanism of spectrum allocation and reduces the required time to successfully acquire a broadcast license.

a. Background

For the first fifty years of government spectrum regulation, licenses were awarded based on Commission hearings. Eventually, the increased demand for licenses overwhelmed the slow allocation process. In 1982, the FCC initiated a lottery system for spectrum allocation.

The lottery placed no restrictions on participation. The Commission believed that a secondary market for awarded licenses would allow the telecommunications companies to sort out the licenses amongst themselves. The lottery system did not perform as intended and the Commission received constant scrutiny about the process from Congress. Under the lottery process, a group of dentists, with no intention of using the spectrum, was awarded a license for cellular services on Cape Cod. The group sold the license to Southwestern Bell for $41 million.[30]

Members of Congress recognized the value of spectrum licenses. Pressure from legislators forced the FCC to research and implement a more fair and profitable method for allocating spectrum licenses. The FCC consulted with game theorists and mathematicians in order to create an auction scheme that was fair to everyone involved in

[29] "About Auctions." *The Federal Communication*. 9 August 2006.

[30] Erica Klareich, Kenneth Arrow, Robert Aumann, John McMillan, Paul Milgrom, Roger Myerson, and Thomas Schelling. "The Bidding Game." *National Academy of the Sciences, Beyond Discovery: The Path from Research to Human Benefit*. (March 2003): 6.

the auction process. "Auctions, which tend to award the prize to the bidder who values it most and to extract a lot of money along the way, seemed like the way to go."[31]

The idea of auctioning of spectrum was not well received by the wireless communications industry. They did not believe that the new allocation scheme would see the results as predicted by the FCC and Congress. "The Federal Communications Commission estimated that the airwave spectrum was worth about $10 billion, but telecommunications industry leaders scoffed at the idea that they would pay anywhere near that sum."[32]

The first auction of wireless broadcast licenses occurred in July of 1994 at the Omni Shoreham Hotel in Washington, D.C.[33] Bidding for the first ten licenses increased by the tens of millions of dollars to a cost of $617 million for the first ten small licenses. By 2001, auctions of wireless spectrum had netted the United States Department of the Treasury approximately $42 billion.[34]

The FCC's policy of auctioning spectrum licenses was a great success. Not only did it provide a mechanism for the government to collect revenue from spectrum use, but also it created a more efficient process for companies to introduce new technologies into the consumer telecommunications market. "Within two years of the first spectrum auctions, wireless phones based on the new technologies were on the market."[35]

b. Bidding

Currently, the auction process is conducted in multiple rounds and continues until there is no change in bids for one round of bidding. Simultaneous Multi-Round Bidding (SMR) allows for bidders to see the results of each round of bidding and

---

[31] Erica Klareich, Kenneth Arrow, Robert Aumann, John McMillan, Paul Milgrom, Roger Myerson, and Thomas Schelling. "The Bidding Game." *National Academy of the Sciences, Beyond Discovery: The Path from Research to Human Benefit*. (March 2003): 6.

[32] Ibid., 1.

[33] Ibid.

[34] Ibid.

[35] Ibid., 7.

adapt their bidding strategy based on accurate demand information. The process also allows for package bidding so a user can bid for multiple licenses in one spectrum in order to minimize the awarding of chunks of spectrum that cannot be used for its intended purpose.

(1) Simultaneous Multi-Round (SMR) Bidding. SMR bidding makes all licenses available for simultaneous bidding. "Simultaneity provides buyers with information about the prices of relevant complements and substitutes, and allows them to act on information to combine complementary spectrum into the most efficient packages and to choose among suitable spectrum."[36] Following the conclusion of each round of bids, the Commission posts results on the Internet. The SMR process provides feedback about the value of licenses being auctioned to the bidders. This process of auctioning spectrum continues for an undefined number of rounds. Bidding continues until a round of bidding is completed without a change in bids.[37] Without simultaneity, a bidder could end up not bidding on an item early because they overestimate the price of the other desired item to be auctioned later or they could win the earlier item at a high bid and not have enough capital available to win the auction for the other spectrum.

(2) Package Bidding. The FCC allows bidders to bid on multiple licenses in a bundled package. "Package bidding is appropriate when there are strong complementaries among licenses for some bidders and the pattern of those complementaries varies among bidders. Under these circumstances, package bidding yields an efficient outcome, ensuring the licenses are sold to those bidders who value them most."[38] Package bidding allows for a bidder to bid on the entire amount of spectrum desired and win all-or-nothing and, "facilitates efficient aggregation of spectrum across geography ad bandwidth."[39] For example, a group of spectrum may be worth a certain amount if both are available. However, without their compliment, they

---

[36] Evan Kwerel and John Williams. "A Proposal for a Rapid Transition to Market Allocation of Spectrum." *Federal Communications Commission, OPP Working Paper Series* 38 (2002): 11.

[37] "About Auctions." *The Federal Communication*. 9 August 2006.

[38] Ibid.

[39] Kwerell and Williams: 14.

are not worth as much separately. Without package bidding, a bidder may win part of the desired spectrum at a higher cost than the actual value of that piece.

c. Auction Timeline

Table 2 outlines the FCC's auction process from announcement of the available licenses to the public notice of auction winners of licenses.

Time	Action
4-6 Months Prior	Public notice is released announcing auction -seeking public comment on procedures -in accordance with the Budget Act of 1997
3-5 Months Prior	Second public notice is released by the FCC -announces terms, procedures, and conditions
60-75 Days Prior	Seminar is held by the FCC -introduces auction rules and processes -answers questions from potential bidders
45-60 Days Prior	Short Form Application is due to the FCC -required for participation in the auction -contains pertinent company information -intention of desired licenses
30-40 Days Prior	Applicants notified of the status of their application -accepted, incomplete, or rejected
3-4 Weeks Prior	Short Form Application resubmission -incomplete applications Deposit of funds by potential bidders -funds available for auction
10-14 Days Prior	FCC releases notice of qualified bidders -desired licenses and available capital for bids -information sent to each applicant
1 Week Prior	Auction registration for qualified applicants -FCC distributes all tools necessary for auction

2-5 Days Prior	Mock auction is conducted -verifies participants are familiar with the process
Auction Day	Auction is held by the FCC over the Internet
Post Auction	FCC publishes public notice of results -winning bid and amount owed -10 days to fulfill payment requirement

Table 2. Auction Timeline[40]

C. SPECTRUM POLICY TASK FORCE (SPTF)

In 2002, the FCC launched the SPTF, "to assist the Commission in identifying and evaluating changes in spectrum policy that will increase the public benefits derived from the use of radio spectrum."[41] Chairman Michael K. Powell issued a statement outlining the need for regulators to keep pace with the rapidly advancing wireless technologies.

> The government has an almost impossible task of trying to keep pace with the ever-increasing demand for spectrum and continuing advances in wireless technologies and applications. In the fast-moving world, the Commission cannot rely on outmoded procedures and policies. We must establish new ways to support innovations and the efficient, flexible use of spectrum. While the Spectrum Policy Task Force has a difficult task ahead of it, I am pleased that it is making significant progress and that it is moving forward with a work plan.[42]

The Task Force was comprised of senior staff from multiple commissions and bureaus and offices. Among its participants were included engineers, attorneys, and economists.

---

[40] "About Auctions." *The Federal Communication*. 9 August 2006.

[41] Michael K. Powell. "FCC Chairman Michael K. Powell Announces Formation of Spectrum Policy Task Force." News Release. The Federal Communications Commission, Washington, D.C. 6 June 2002

[42] Ibid.

The SPTF Report stated that to "increase opportunities for technologically innovative and economically efficient spectrum use, spectrum policy must evolve towards more flexible and market-oriented regulatory models."[43] Its aim was to modernize the policies of how spectrum resources are allocated and utilized.

The Task Force issued their report in November of 2002. It issued three principal recommendations for future wireless spectrum allocation:

> (1) Migrate from current command and control model for spectrum regulation to market-oriented, exclusive-rights and unlicensed device/commons models;
>
> (2) Implement ways to increase access to spectrum in all dimensions for users of both unlicensed devices and licensed spectrum; and
>
> (3) Implement a new paradigm for interference protection.[44]

The SPTF Report detailed three specific approaches for implementing more market-oriented schemes for allocation of the utility: exclusive-use, commons, and command and control. Exclusive-use allows for, "exclusive and transferrable flexible use rights for the specified spectrum within a defined geographic area; technical rules primarily govern those rights to protect spectrum users against interference."[45] The commons approach to spectrum allocation provides an unlimited number of unlicensed users to, "share frequencies; technical standards or etiquette governs usage right, but there are no rights to protection from interference."[46] The command and control model is the traditional model of FCC spectrum regulation in the United States. "It limits allowable uses based on regulatory judgment."[47]

---

[43] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 564.

[44] "FCC Task Force Reports on Spectrum Policy Reform Progress And Initiatives." News Release. The Federal Communications Commission, Washington, D.C. 13 November 2003.

[45] Thomas W. Hazlett, Thomas W. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 68.

[46] Ibid., 69.

[47] Ibid.

The objectives of the Task Force were to encourage the best use of the spectrum to promote growth, rapid deployment of innovative and efficient technologies in communication, ensure efficient use of the spectrum, and to promote transparency and awareness in spectrum activities. Additionally, the Task Force sought future input from experts and to collaborate with all disciplines and institutions to improve upon SPTF recommendations and implement future ideas.[48] Some of the implementation of the Task Force policies focused on future FCC initiatives, including removing secondary barriers to implementation of spectrum policies through authorized leasing and transfer of unused portions of licenses, additional spectrum for unlicensed use, additional rural access to wireless communications technologies, and additional studies of receiver performance to make more efficiently use of the electromagnetic spectrum.

One year after the report was issued, the FCC reported on the progress towards implementation of Task Force initiatives. In that first year, the FCC worked towards improving access to spectrum in rural areas, specified immunity performance standards for radio receivers, established an interference temperature metric, designated additional spectrum for unlicensed use, and issued a final set of rules for establishing secondary markets. The Task Force encouraged the FCC to seek input from consumers and companies, using technology, regarding future policies. The Commission would seek input through public workshops, actively seeking comments on issued reports, and through a SPTF web site.

In 2006, the FCC's Wireless Telecommunications Bureau (WTB) repeated the Task Force's goals of further advancement in improved spectrum allocation. At the FCC, the WTB is

> responsible for all FCC domestic wireless telecommunications programs and policies, except those involving satellite, public safety communications, and broadcasting. Wireless communications include cellular, paging, broadband PCS, advanced wireless services, 700 MHz,

[48] "One Year Later." Federal Communications Task Force Reports on Spectrum Policy Reform and Progress, Washington, D.C. 13 November 2003.

broadband radio service/educational broadband service, microwave, amateur radio, and air-ground radiotelephone service.[49]

According to the WTB 2006 agenda, their mission is to, "promote competition, efficiency, and innovation in the wireless marketplace for the benefit of consumers and the advancement of commercial, private, and public safety operations."[50] The WTB points to performance metrics in the wireless communications industry to support their claim that initiatives established by the SPTF have led to improved use of the electromagnetic spectrum. Over a five-year period, from 2001 through 2005, the WTB claims that wireless communications markets in the United States saw an increase of 101% in the number of wireless subscribers, 126% increase in revenue, 41% increase in the number of jobs in the industry, and a 182% increase in the number of minutes of use by subscribers. Additionally, costs to make a wireless call decreased by 8 cents per minute.[51] Because of the successes of the industry, the WTB encouraged future growth through more auctions and use of unlicensed spectrum bands.

Following five years of increased focus on the commons approach to wireless spectrum allocation and more auctions, the FCC stopped progress towards completely implementing the SPTF initiatives. In 2007, the Commission halted all further progress towards achieving more market-based allocation of spectrum in wireless communications. The agency effectively ignored the "increasing dissatisfaction with the current approach to spectrum management which suppresses competitive entry, blocks efficient transfer of spectrum to higher value use, and insulates old technologies from innovative challenge."[52] Although they have not fully implemented the recommendations of the SPTF, the FCC has re-stated that one of its goals is to implement innovative licensing models in order to eliminate barriers to competition in the wireless communications market.

---

[49] The Federal Communications Commission. *Strategic Plan 2009-2014*. 24 June 2008.

[50] "Wireless Telecommunications Bureau Agenda Meeting." The Wireless Telecommunications Bureau, The Federal Communications Commission, Washington, D.C. 20 January 2006.

[51] Ibid.

[52] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 552.

D. FCC STRATEGIC PLAN (2009-2014)

The FCC has established six strategic areas of emphasis for the next five years. These goals are to make improvements in the following areas: broadband, competition, spectrum, media, public safety, and modernization of the FCC.

The FCC aims to ensure that all Americans should have affordable access to reliable broadband services. "Regulatory policies must promote technological neutrality, competition, investment, and innovation to ensure that broadband service providers have sufficient incentive to develop and offer such products and services."[53] More competition in the market is beneficial to the domestic and international economies. The Commission urges more competition in all aspects of their regulated industries through better and more efficient regulations. In media, the FCC promotes competition, diversity, and localism. An additional emphasis is placed on the transition to all digital media delivery. The Commission hopes to create a critical infrastructure that is reliable and available during all crises and emergencies. The last goal is the overall modernization of the FCC. "The FCC shall strive to be a highly productive, adaptive, and innovative organization that maximizes the benefit to stakeholders, staff, and management from effective systems, processes, resources, and organizational culture."[54] The focused areas of competition and spectrum are important to future improvements in an improved system of spectrum allocation.

1. Competition

Competition in communications directly supports the national economy. Over the next five years, the FCC aims to foster sustainable competition across the entire communications sector and greater promotion of universal services. Their method for implementing more competition in the communications sector includes establishing rules that promote open and through competitive entry and through consistent enforcement of

[53] The Federal Communications Commission. *Strategic Plan 2009-2014*. 24 June 2008: 3.

[54] Ibid.

regulatory framework. They also emphasize promotion of universal services, which will allow greater access to resources at affordable rates.[55]

2. Spectrum

The Commission has established a rigorous set of goals for spectrum strategy. Implementation depends upon an increased emphasis on flexible allocation policies that promote efficient and effective use of the spectrum. The Commission plans on advancing the utilization of spectrum for unlicensed use and improving the common Commission goal of timely and effective regulation.

Several steps are identified toward achieving more efficient and effective use of the spectrum. The Commission plans to achieve this through an increased number of spectrum bands available for shared use by compatible technologies, new and innovative licensing models that reduce entry barriers to competition, improved interoperability for public safety, minimization of harmful interference, and encouraging new technologies.

The FCC identifies improving effective and timely licensing activities as a means to achieving improved spectrum allocation. To this end, they propose utilizing electronic technologies for faster filing of documents with the Commission and information sharing regarding regulations. A goal is to further advance opportunities for new uses of spectrum resources while minimizing harmful interference. Vigorous enforcement of policies is necessary to ensure full compliance with all spectrum regulations.

E. CURRENT REGULATION ISSUES

Former FCC Commissioner, Harold Furchtgott-Roth, points out in his book, *A Tough Act to Follow?*, that the structure of the FCC does not allow it to effectively regulate the communications industry. The powers granted to the Commission by the Telecommunications Act of 1934 allow it to create the rules, enforce the rules, and interpret infractions of the rules, effectively granting the FCC all the power of the Federal

[55] The Federal Communications Commission. *Strategic Plan 2009-2014*. 24 June 2008: 8.

Government when it comes to regulating spectrum. The combination of powers granted to the FCC removes the incentive for the Commission to perform any of its assigned tasks efficiently.[56]

Congress is charged with oversight of the FCC. However, the FCC has historically been slow to respond to the demands of Congress and prefers to act like an autonomous agency. The Judicial Branch is hesitant to overrule the FCC in technical matters. Compounding the impact of these issues, the FCC cannot adequately correct its own mistakes made in the regulation process.

Furchtgott-Roth points out major problems with the FCC in its current form. These problems were identified and the Telecommunications Act of 1996 attempted to correct them, but did not adequately address the major problems at the FCC. Two issues that create major obstacles in dealing with the FCC are the unending bureaucracy problem and the technology retardation problem.[57]

The FCC is not in a hurry to respond to requests for action. The Judicial Branch will not intercede until all routes are completely exhausted, which exacerbates the problem. Congress accepts the fact the FCC is slow, since the Commission has historically failed to react to Congress' requests for action.

According to Furchtgott-Roth, the FCC has retarded the growth of technology. The FCC has a long documented history of hindering advances in technology. The following section outlines specific cases where the existence of FCC regulation impacted the growth of the wireless communications industry.

1. FCC History of Obstructing Innovation

There are numerous examples throughout the history of the FCC of regulating decisions hindering the growth of technology. This section lists a few egregious

[56] Harold W. Furchtgott-Roth. A Tough Act to Follow?. Washington, D.C.: The American Enterprise Institute Press, 2006: 18.

[57] Ibid., 23-4.

examples of how decisions not based on fact, but rather political pressure and ideology, impacted the growth of beneficial technology.

1. Frequency Modulation (FM)

In the 1930s, Edwin Armstrong hypothesized that the use of FM could reduce or eliminate the static associated with amplitude modulation (AM) broadcasts. "In 1935, Armstrong gave a public demonstration of his FM at the conference of the Institute of Radio Engineers. The audience was treated to a performance of live music transmitted with remarkable clarity, better than had been heard before without static."[58] Armstrong applied for a license with the FCC. RCA and the National Broadcasting Corporation (NBC) lobbied against issuing Armstrong a license. RCA and NBC saw FM as competition since it provided a better quality broadcast.

In 1940, 150 licenses had been applied for with the FCC and only twenty stations were broadcasting using FM technology. The fight to implement FM in the marketplace had cost Armstrong $700,000 to $800,000, with no return on his investment as of 1940.[59] "It took a full generation for FM to develop into the pervasive and flourishing format it is today."[60]

2. Microwave Technology

Microwave technology introduced competition into the telecommunications sector by providing phone service that was transmitted over the airwaves instead of through wires. Microwave Communications Incorporated (MCI) believed the emerging technology would introduce competitive phone service into the AT&T monopoly. "The benefits of the new and improved technology were held back by the FCC, by monopoly power, or by a combination of the two."[61] With microwave

---

[58] Bert Lundy. Telegraph, Telephone and Wireless: How Telecom Changed the World. Charleston, SC: Booksurge, 2008: 510.

[59] Ibid.

[60] Harold W. Furchtgott-Roth. A Tough Act to Follow?. Washington, D.C.: The American Enterprise Institute Press, 2006: 24.

[61] Lundy: 515.

licensing, the FCC missed an opportunity to introduce competition into the telecommunications market by rejecting most of MCI's applications for licenses. "Except in limited cases, such as rural areas where AT&T was not providing service, companies other than the common carriers - the Bell System and the independent telephone carriers - were not allowed to go into the telecommunications business with microwaves."[62]

3. Cable Television

The first cable television systems were developed in the early 1950s. For thirty years, "the FCC succeeded in retarding the development of cable television by putting restrictions on the programming cable operators could offer their customers."[63]

4. Cellular Telephone

It took thirty years for the FCC to issue the first license for cellular telephone service. The FCC received the first license request for cellular telephone technology in the 1950s. It wasn't until the 1980s that the FCC approved the first license.[64]

5. Apple and Unlicensed Personal Communication Service (U-PCS)

In the early 1990s, Apple argued that there needed to be more unlicensed spectrum for wireless local area networks (LAN). "Without considering the option that Apple could acquire spectrum rights and configure them for LAN services, the FCC mandated a spectrum, imposed standards (including listen-before-talk), and set power limits."[65] The allocated spectrum has remained virtually unused. "The 30 MHz

---

[62] Bert Lundy. Telegraph, Telephone and Wireless: How Telecom Changed the World. Charleston, SC: Booksurge, 2008: 519.

[63] Harold W. Furchtgott-Roth. A Tough Act to Follow?. Washington, D.C.: The American Enterprise Institute Press, 2006: 24.

[64] Ibid.

squandered on U-PCS would provide billions in annual consumer surplus gains (through lower prices and more minutes of use on wireless phone networks) if PCS operators could acquire them."[66]

Over the years, the cost associated with the delayed deployment of technologies is inestimable.[67] Many applicants were exhausted by the slow response of the FCC and the inability of Congress and the Judicial System to intervene.

F. CHAPTER CONCLUSION

The current form of spectrum regulation requires reform. The bureaucratic system creates unnecessary obstacles to the introduction of new technologies. It also allows for external influence in the decision-making process by the Commission. Even the FCC has stated a strategic goal of implementing innovative property models for spectrum allocation. In the next chapter, some innovative property models are outlined as the basis for establishing an innovative allocation model that eliminates barriers for competition in the electromagnetic spectrum.

---

[65] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 73.

[66] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 73

[67] Harold W. Furchtgott-Roth. *A Tough Act to Follow?*. Washington, D.C.: The American Enterprise Institute Press, 2006: 24.

IV. ACADEMIC PROPOSALS AND THE BENEFITS OF PROPERTY-RIGHTS AND DEREGULATION

This chapter outlines some of the leading proposals for reform in allocating spectrum. The proposals represent fifty years of ideas to make the use of spectrum and allocation process more efficient. They all agree that a property-rights system would provide the best method for allocation, but differ in how exactly to implement a property-rights scheme. This chapter also contains the real-world spectrum allocation examples from Guatemala and El Salvador. In the late 1990s, the two countries implemented property-rights models for spectrum allocation. In this chapter, an analysis of the performance of both markets and measures the effects of liberalization on spectrum markets is presented. The last section outlines the benefits that deregulation has provided across several industries. It also takes a look at the benefits of liberalization in the electromagnetic spectrum markets and lays out key ideas that lead to successful deregulation.

A. RONALD COASE

Nobel Prize winning economist, Ronald Coase first wrote about property-rights in spectrum in his 1959 article, "The FCC." In the article, he contended that the FCC is not capable of managing the electromagnetic spectrum and that the competitive market would best allocate the medium.

In his article, Coase introduced a system of property-rights to regulate the electromagnetic spectrum. His article redefined the debate over broadcast regulation in the United States. He pointed out that the FCC continues to regulate the spectrum according to the initial standards set in the Federal Radio Act of 1927. Regulation has ignored advances in technology, a better understanding of the electromagnetic spectrum, and has relied on an overly-conservative model of regulation that aimed to avoid all interference in wireless communications. He rejected the false notion that FCC regulation serves the public's best interest. "The complex regulatory apparatus developed under the Federal Radio Act of 1927 and re-codified in the Federal

Communications Act of 1934 was built on the flawed assumption that scarce resources-in this case the radio spectrum-had to be regulated by government fiat."[68]

Coase contended that the FCC does not possess the ability to effectively or efficiently regulate the spectrum. The bureaucratic process is slow and provides the FCC too much influence over the decisions about the wireless communications market. "Licenses are not issued automatically but are granted or withheld at the discretion of the Commission, which is thus in a position to choose those who shall operate radio and television stations."[69] Additionally, FCC regulation of the electromagnetic spectrum is not the correct mechanism for optimal performance of the broadcast industry.

> An administrative agency which attempts to perform the function normally carried out by the pricing mechanism operates under two handicaps. First of all, it lacks the precise monetary measure of benefit and cost provided by the market. Second, it cannot, by the nature of things, be in possession of all relevant information processed by the managers of every business which uses or might use radio frequencies, to say nothing of preferences of consumers for the various goods and services in the production of which radio frequencies could be used.[70]

More specifically he pointed out that decisions by the FCC only emerged after long delays, even years. According to Coase, the legacy system of regulation used by the FCC has unnecessarily restricted innovative uses of the spectrum because of a regulatory process that protects incumbents against the introduction of competition into the market.[71]

Spectrum management is a complicated process. On the one hand, rules must be in place that protect against interference, but the rules should not restrict the growth of the industry. Coase claimed the current form of regulation by the FCC inhibited the growth of the wireless industry.

---

[68] Michael R. Fein and David A. Moss. "Radio Regulation Revisited: Coase, the FCC, and the Public Interest." *The Journal of Political History* 15.4 (2003): 390.

[69] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 1.

[70] Ibid., 18.

[71] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 562.

> The problem confronting the radio industry is that signals transmitted by one person may interfere with those transmitted by another. It can be solved by delimiting the rights which various persons possess. How far this delimitation of rights should come about as a result of transactions on the market is a question that can be answered only on the basis of practical experience. But there is good reason to believe that the present system, which relies exclusively on regulation and in which private property and the pricing system play no part, is not the best solution.[72]

1. System of Private Property

The optimum spectrum management system is not necessarily one in which there is no interference. Coase claimed that the purpose of spectrum regulation had not been defined correctly. Instead of a regulation system in the radio industry that aimed to minimize interference, a management scheme should be implemented in order to maximize output.[73] His proposed scheme would treat spectrum licenses like private property and allow the market to govern spectrum allocation.

In his scheme, "the broadcaster would buy the right to use, for a certain period, an assigned frequency to transmit signals at a given power for certain hours from a transmitter located in a particular place… It would certainly make it possible for the person or firm who is to use a frequency to be determined in the market."[74] Since the FCC regulatory system inhibits the growth of industries that rely upon use of the frequency spectrum, a new regulatory system that endorses property-rights for radio spectrum is needed. An efficient system would be to establish a set of legal rules for operating and then let the institution of private property and the pricing system resolve interference issues. By treating spectrum rights as property, the legal system would sort out disputes as it does with disputes over land use and ownership. Coase believed that a system of regulation infringed on the individual's ability to determine the best utility of

---

[72] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 34.

[73] Ibid., 27.

[74] Ibid., 25.

their licensed spectrum and it would be better to allow license holders to utilize better technology and mutual agreements to make more efficient use of the electromagnetic spectrum.

2. Method of Implementation

Coase proposed a free-market system of license distribution with minimal restrictions imposed only after the exhaustion of free-market tools. "If the problems faced in the broadcasting industry are not out of the ordinary, it may be asked why was not the usual solution (a mixture of transferrable rights plus regulation) adopted for this industry?"[75]

His method for implementing this system should be governed by two basic principles: the free-market will determine best use and pricing in wireless communications and restrictions should not be imposed without exhausting all free-market tools of resolution.

In his proposal, he stipulated that the frequency band licenses be disposed of to the highest bidder. A system of auctioning off broadcast licenses would determine the accurate price for spectrum property using free-market principles. The best use of the utility and accurate pricing would be determined through competitive pricing.

He also believed that a restriction on the use of a property inhibits the potential growth in the wireless spectrum and that a bureaucratic process should not impose unnecessary restrictions. Special regulation should not be imposed without exhausting free-market tools and just cause.

3. Shortcomings of the FCC Regulation Model

Coase pointed out issues with the model of regulation that the FCC uses, as well as the structure of the regulating agency. He believed that the FCC should not have complete oversight of the entire allocation process; the Judicial System was not able to

[75] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 30.

adequately address the issue before severe regulation was imposed; lawmakers did not sufficiently understand the problems presented in wireless communication; and, the FCC was susceptible to outside influences in the decision-making process.

Coase used the comparison of spectrum management to property and business laws. Most every allocation scheme requires administrative oversight but not complete regulation. Property owners are subject to zoning laws and business owners face regulations; but in spectrum allocation the FCC has total authority in all matters. The decision to extensively regulate the wireless spectrum was made with the Radio Act of 1927, prior to the courts ever having the ability to impose limitations to successfully settle interference disputes. "No doubt, in time, statutes prescribing some special regulation would also have been required. But this line of development was stopped by the passage of the 1927 Act, which established a complete regulatory system."[76]

In reviewing the testimony and written history of the debates leading to the Federal Radio Act of 1927, Coase concluded that the policy makers did not fully comprehend the situation they were governing.[77] He pointed out two things: that regulation was a reaction to the politicians not understanding the problem; and, that if they did not take action, they could never regain control, "What does not seem to have been understood is that what is being allocated by the Federal Communications Commission, or, if there were a market, what would be sold, is the right to use a piece of equipment to transmit signals in a particular way."[78]

His final problem with the FCC's role in regulating the wireless spectrum was that the FCC is susceptible to outside influence. "The Federal Communications Commission has recently come into public prominence as a result of disclosures before the House Subcommittee on Legislative Oversight, concerning the extent to which pressure is brought to bear on the Commission by politicians and businessman (who often

---

[76] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 31.

[77] Ibid.

[78] Ibid., 33.

use methods of dubious propriety) with a view to influence its decisions."[79] He implied that if the broadcast rights were allocated to the highest bidder in a property-rights scheme the improprieties would disappear.

B. ARTHUR DE VANY

In 1968, the government released a document titled, "The President's Task Force on Communications Policy." A group of people who worked as consultants to the staff wrote a paper to promote the idea of utilizing property-rights in spectrum in order promote public support and possibly get Congressional approval for experimental deployment of the idea. The paper was a collaboration of five authors, however Arthur De Vany gets singular credit for advancing the ideas presented in this section. This paper refers to the ideas as De Vany's, but credit should also go to the other authors as well: Ross Eckert, Charles Meyers, Donald O'Hara, and Richard Scott.

In a 1969 article, Arthur De Vany introduced a practical implementation scheme for spectrum management. He and his colleagues presented a proposal that defined the physical and economic characteristics of spectrum, applied a general economic theory of property to spectrum allocation, defined a system of spectrum-use rights, analyzed legal and transactional problems associated with the proposed scheme, and introduced legal methods for the government to dispose of the spectrum rights.

> The operation of a market in spectrum use depends, as we have noted, on the creation of a property system in the spectrum; that is, it depends upon the specification of a system of rights and duties of users sufficiently certain in meaning, sufficiently enforceable, and sufficiently valuable that people are willing to spend money to acquire the right.[80]

The authors noted that it was the confused condition of the radio industry that led directly to the regulation of the industry. De Vany saw two problems with the FCC's regulation of the wireless spectrum. First, the rights allocated in licenses contain few

---

[79] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 36.

[80] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1505.

incentives to make efficient use of the allocated spectrum. Second, the regulatory practices that were adopted in 1927 have not kept up with advances in technology. Proponents of deregulating the wireless spectrum argue that the market process will encourage more efficiency and better satisfy consumer needs. Opponents believe that electromagnetic waves are too difficult to contain in order to effectively manage an allocation policy that is usable. They still fear the pre-1927 chaos that existed in the radio industry.

Implementation of De Vany's proposal of property-rights requires three elements. First, the rights are valuable and unambiguous, as well as compatible with the special properties of the electromagnetic energy. Second, there is a legal mechanism for enforcement of these rights. Third, the definition of rights provides for the initial distribution of government-owned spectrum to the public for use.[81]

One of the most important ideas that De Vany introduced was his definition of exclusive property, with respect to spectrum allocation. He identified three characteristics, time, coverage area, and bandwidth, that make each piece of the electromagnetic spectrum unique for use in a property-rights scheme. He referred to this model as the Time-Area-Spectrum (TAS) model. Each TAS entity, or property, refers to the time period of allowable transmission, the geographic area where the waves are spread, and the frequency band used in transmission.[82]

He believed that the economic and technological benefits associated with property-rights more than outweighed the risks associated with property-rights to allocate spectrum. Additionally, improvements in technology have further mitigated the risks associated with deregulation of the electromagnetic spectrum.

> Several precautions can be taken to reduce interference from such extraneous radiation. First, the rate of transmission and the method of modulation must be consistent with the time and bandwidth available within the TAS package. Second, careful design of transmitters can avoid

[81] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1501.

[82] Ibid., 1502.

> the generation of spurious frequencies; proper filtering and shielding can reduce sensitivity to such spurious signals. Third, adequate maintenance service for both transmitters and receivers can assure their proper functioning.[83]

Experimentation with property-rights is warranted considering the inefficiency of the current system. The current shared use of the unlicensed spectrum bands further supports De Vany's assertion. Chaotic broadcasting conditions have not been the result; but instead, companies have cooperated in order to make better use of the asset allocated for use in the unlicensed spectrum.

1. Economic Theories for Spectrum Use

There are four economic characteristics that provide inherent value for the allocated resource: exclusivity, costs of exchange and enforcement, externalities, and flexibility. From these characteristics a property-rights system must be devised to take into account all the benefits that are provided by each characteristic as well as devise limitations in order to create the most beneficial allocation system. "A particular resource use can be more costly (or less rewarding) under one set of rights and duties than under another; and the more costly any given behavior is, the less of it we should expect to observe."[84]

a. Exclusivity

The idea of exclusivity is that the allocated resource will be most valuable when the right to use it is exclusive to one user. It is also more valuable when there are no exclusions placed on the manner that the owner can use it. The exclusive license allows the owner to exclude others from using their resource.[85] It was because of non-exclusivity of spectrum-use that led to the initial government regulation by the Federal

---

[83] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1504.

[84] Ibid., 1505.

[85] Ibid.

Radio Commission, later the FCC, in 1927. The regulation solution was to grant exclusive rights with no flexibility in use, and little flexibility in operation. De Vany's solution proposed exclusive rights without the economically inefficient restrictions.

b. Costs of Exchange and Enforcement

The aim of the spectrum allocation policy should be to ensure that minimal costs are involved to exchange rights or monitor the spectrum in order to promote efficient use of the spectrum policy.[86] If the rights are able to be freely exchanged and divided at low cost, the owner of the rights will more likely devote his or her assets to their most valuable use. By applying economic cost analysis, a transaction will occur only when the cost of the transaction is less than the economic benefit foreseen by making the transaction. Lower costs in the transfer of rights will maximize the potential use of all the resources allocated in the spectrum.

c. Externalities

Externalities are actions by others in the area whose actions impact your business or property. There are beneficial and detrimental externalities. For example, if a factory pollutes the water upstream of a farmer, the polluted water supply is a detrimental externality to the farmer. If a beekeeper increases production, the positive effect on the neighboring apple orchard is a beneficial externality.[87]

Externalities are an important aspect in the electromagnetic spectrum since radio waves cannot be completely confined and predicted. De Vany asserts the establishment of property-rights in the electromagnetic spectrum must allow for contracting between rights-holders in order to resolve interference disputes efficiently.[88]

---

[86] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1507-08.

[87] Ibid., 1509.

[88] Ibid.

d. Flexibility

De Vany outlined three categories of property-rights and their degrees of flexibility. The first category of property-rights is prohibited activities. The second is permitted activities as part of a right. The final category is activities permitted if the consent of other parties is obtained.[89]

He stated that activities should not be placed in the category of prohibited actions unless there are enough affected parties that the exchange of rights costs are so high they would prevent the exchange. The second category is the most flexible for the individual; however, if the collective group is afforded the same flexibility, the rights of the individual may be infringed upon.[90] The goal of a property-rights system is to provide a balanced scheme that allows for individual flexibility yet provides protection for each issued license to operate according to its definition. "The primary problem in designing a market system is not to decide whether an activity should be placed in Category 1 or Category 2, but to define property-rights so that it will be economically attractive to place an activity in either Category 2 or Category 3."[91]

e. Criterion for the Definition of Property-rights

In devising a system of property-rights for use in spectrum allocation, there are tradeoffs that must be considered. It would be possible to implement a plan that contains less costly enforcement means, but it is done at the cost of less flexibility and reduced transferability. The goal of the property-rights definition is to maximize the social value of production from use of the electromagnetic spectrum.

---

[89] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1510.

[90] Ibid.

[91] Ibid.

2. Proposed Property System

In De Vany's proposal for property-rights, he analyzed a realistic implementation for allocating spectrum and provided alternative definitions of property-rights with respect to spectrum allocation. He justified his selection of the most beneficial model against other definitions he considered.

a. Property Definition

The definition of the property is broken down into three characteristics, as noted earlier: the time allowed to transmit, the geographic area where propagation of electromagnetic waves is permitted, and the permissible frequency band of transmission.

(1) Time Rights. The time characteristic specified that time rights should be allocated to license holders for the entire twenty-four hour period of each day. The license holder and customer would be able to make sub-arrangements without restriction by the government-issuing agency.[92]

(2) Area Rights. The characteristic of area defined two important features of the property specification. The license holder would possess the exclusive rights to radiate in an area, subject to the constraint that the field strength is not above some allowable value at any point outside the designated area. Secondly, the rights holder would be free from fields exceeding the same allowable value at any point within their geographic boundary emitted from external areas.[93] Realistic electromagnetic boundaries do not follow straights lines and legal boundaries, but De Vany's proposal would have enforced straight-line boundaries. Lower enforcement costs would be involved with simple geographic boundaries in order to eliminate un-zoned areas where squatters could increase enforcement and exchange costs. Squatters find unlicensed areas and obtain the rights in that area for the sole purpose of detecting emissions from adjacent areas. This allows them to bring litigation because their property-rights were

[92] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1512.

[93] Ibid., 1513.

infringed upon. Allocating straight-line boundaries minimizes the amount of pockets where licenses can be established for the purposes of eliciting payment from an adjacent license holder or filing lawsuits. These frivolous lawsuits would unnecessarily drive up all costs associated with the spectrum allocation scheme.

(3) Spectrum Rights. Adjacent spectrum channels emit energies that may infringe upon adjoining frequencies. The level of spillover needs to be limited in order to provide protection against interference. Some spillover should be allowed in order to ensure that the property model maximizes the use of the electromagnetic spectrum, yet at the same time provide a maximum level of spillover in order to protect the adjacent user's right to broadcast freely. De Vany defined the spectrum rights as the frequency band where the licensee is permitted to transmit. It established a set threshold where transmitting above that level would not allowed in adjacent bands. De Vany's definition of spectrum rights is illustrated in Figure 3.

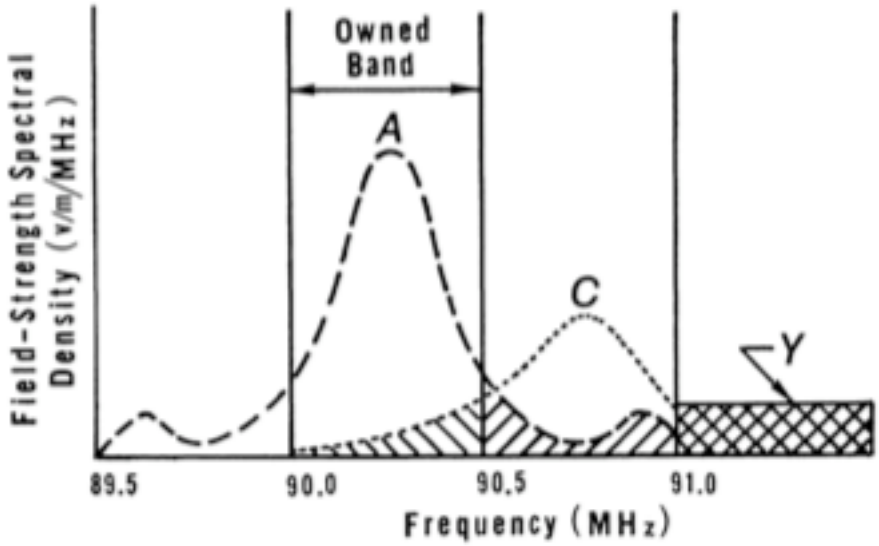

Figure 3. Example Spectrum Band[94]

[94] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1515.

"Within a given area the right specified gives A the right to originate radiation in area A over the band of, say, 90.0 to 90.5 MHz, with a field strength not greater than Y v/m in another band, such as 90.5 to 91.0 MHz, owned by C."[95]

The optimal TAS information has not been prepared yet, but through market exchanges the licensees can make arrangements in order to maximize the spectrum use through TAS rights. Initial best engineering judgments should be made for an optimal TAS package, however, subsequent changes can be optimized in the marketplace to account for the dynamic environment; changes in population concentration, demand, costs, and technologies. TAS definition of property-rights deals with the exclusivity and externality problem in allocating spectrum.[96]

b. Spectrum Use Implications

Opponents of property-rights in spectrum allocation claim that the realistic physical properties of electromagnetic waves make it impossible to use property-rights in spectrum allocation. De Vany looks at multiple problems associated with electromagnetic wave properties, such as variation in wave propagation, multipath propagation, inter-modulation interference, and the size of the service area.

(1) Multipath Propagation. It is possible that a wave will take two paths to reach the same point. This results in a field strength greater that the maximum allowable and results in violating the license agreement. This same rule that will require you to limit your field strength because of the multiple paths that a wave takes also protects your broadcast rights against neighbors experiencing the same multipath propagation problem.

(2) Inter-modulation Interference. Inter-modulation occurs when two frequencies combine to interfere with a third frequency in the same time and area location. This type of interference is mostly caused by the proximity of the transmitters. De Vany proposes a solution where the third party whose entrance causes the problem

[95] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1515-16.

[96] Ibid., 1518.

should be held accountable to fix the problem. In order to limit litigation costs, the easiest solution is to put responsibility on the last person to the table in order to ensure continued operation of all parties involved. In his solution, the third party could continue to transmit and pay damages to the affected parties, shift operating frequency, pay the others to shift their operating frequency, or pay for better isolation of the affected transmitters. When there is no physical link determined to cause the interference, the third party would be held responsible to determine the solution, as well.

(3) Service Area Size, Boundary Effects, and Optimal Frequency. Signal-to-interference ratios are highest at the boundaries. If two adjoining geographic areas are transmitting identical frequencies, it can create a zone along the boundary where interference precludes both transmissions. Lower frequency transmission will reach a larger area, but have a larger probability of interfering with adjacent signals of identical frequency near the boundary. One technique to resolve such an issue is to use lower frequencies for larger, less dense, areas and higher frequencies in more densely populated areas to minimize interference zones at the boundaries. Table 3 illustrates the size of a serviceable area for a given frequency, range, and signal quality. For a given broadcast radius, frequency, and acceptable noise level, the table shows the percentage of the coverage area where the signal is received.

Frequency	50 MHz		400 MHz		1,000 MHz	
Signal-to-interference ratio ...	100:1	1,000:1	100:1	1,000:1	100:1	1,000:1
Radius of circular area:						
12.5 miles	33	1	61	19	70	34
25.0 miles	62	19	79	52	84	63
37.5 miles	74	39	86	66	90	74
50.0 miles	80	52	89	74	92	80

Table 3. Percentage of Circular Broadcast Area Receiving Acceptable Signal[97]

[97] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1524.

There are additional factors to consider when determinging the optimal frequency for use. Lower frequencies allow for a longer transmission radius while broadcasting at a lower power. Economic and physical constraints will keep towers to appropriate size for desired conditions.

3. Alternative Definitions Considered

In choosing the TAS model for his property-rights proposal, De Vany investigated three alternative approaches; a zero-limit definition, residue definition, and the boundary-positive-limit definition. The zero-limit definition allows no spillover of frequency into adjacent areas and limits the licensee's flexibility unnecessarily. The residue-definition makes the owner of a property right responsible for all boundary emissions from their geographic location, whether emitted by them or not. This type of enforcement results in extremely high enforcement and exchange costs. In the boundary-positive-limit definition, the signal strengths are only measured at the boundaries and result in stricter enforcement and less flexibility. This does not provide an adequate level of protection from infringing interference.[98] De Vany rejected these possibilities because they all had higher costs associated with each of them and did not provide the necessary protection and flexibility of enforcing a maximum field strength limit outside the licensed geographic area.

4. Special Legal Aspects

A property-rights system must assert general legal rules to ensure that the market allocates resources efficiently. The general statement of purpose should state that the goal of the property-rights system is "to create property interests in a designated portion of the spectrum in order to promote market allocation of this resource."[99] Courts and all administrative agencies should be directed to interperet this statute to achieve the stated objetive. This includes defining an agency to define property interests in spectrum (TAS

[98] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1527-29.

[99] Ibid., 1529.

packages), create and oversee purchase methods, declaration of user rights, a central collection of public rights exchanges, and a limit on the duration of a TAS package. The declaration of the TAS user's rights should include the following stipulations: the owners may agree to boundary changes without third party authorization, simply notification; when rights are transferrable; authorization for owners to mutually agree to signal increases and decreases; transferability of all or part of the property-rights between parties; and no restrictions on the use of technology or antenna limitations.[100] A central collection database should be maintained that tracks TAS package changes that is accessible to the public. Finally, he proposes a time limit fot the TAS rights to expire or, more specifically, a rental agreement. He ultimately believes that perpetual rights is the ideal process but recognizes the government must maintain some minimal level of control over the spectrum to recapture wealth and spectrum due to failure. Therefore, he believes that a system of rent over a long period is a more realistic approach.[101] This allows for the government to re-allocate resources that are being wasted through default.

C. PHILIP WEISER AND DALE HATFIELD

Philip Weiser is a law professor with a background in telecommunications policies. Dale Hatfield has over forty years of experience in the telecommunications sector and served at the FCC from 1997 through 2000. He served as Chief of the Office of Engineering and Technology prior to his retirement from government service. Recently, the two published an article outlining their proposed scheme for improving spectrum allocation.

The same spectrum regulation scheme has been in effect since the regulations were initially established in 1927. One of the first proposals for a free-market approach to spectrum allocation ocurred over fifty years ago when Coase first criticized the current spectrum regulation and called for tradeable property-rights. Even the FCC's own Spectrum Policy Task Force has called for replacing the restrictive scheme. Although the

[100] Arthur S. De Vany, Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1530.

[101] Ibid., 1531.

call for reform is overwhelming and desperately needed, the FCC halted progress towards a implementing a liberalized spectrum allocation scheme in 2007. The agency effectively ignored the "increasing dissatisfaction with the current approach to spectrum management which suppresses competitive entry, blocks efficient transfer of spectrum to higher value use, and insulates old technologies from innovative chalenge."[102]

Most would agree that implementing property-rights for spectrum allocation would be the most beneficial, Weiser and Hatfield contend that a more complex model, than the classic model of tresspass law, needs to be developed in the context of real property. "Policy makers must develop a set of rights and remedies around spectrum property-rights that reflect the fact that radio signals defy boundaries and can propagate in unpredictable ways."[103] They contend that the new scheme must not only create a viable implementation of a property system, but must protect licensees from interference. Their proposal includes complex predictive modeling, using computer simulation, to ensure that interference will not occur under any proposed licensing scheme. Additionally, they provide an outline of the type of regulating body required for the enforcement of their regulation scheme.

1. Current Issues

In general, people do not know how wireless technology works or how it is regulated. The FCC, as it regulates today, is inefficient and protects incumbents from competition in the markets. There are unacceptable delays in the current system that cause long and costly delays in launching new technologies. The financial effect on the wireless communications industry is ghastly. "The loss from delays in the rollout of more and better services occasioned by the legacy model of spectrum regulation was estimated in 1994 to be as high as $33.5 billion."[104] The FCC maintains control over all

[102] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 552.

[103] Ibid., 553.

[104] Ibid., 555.

aspects of spectrum regulation. The traditional command-and-control model allows for all decisions affecting the industry to be made by one governing body: the FCC.

a. Weaknesses of the Current Regulation Model

The current FCC regulation of the wireless spectrum is technically, economically, and politically inefficient. The current model is based on the "wise man" theory of regulation.[105] It is the government that allocates the spectrum for wireless services like cellular telephone, broadcasting, and personal mobile devices. The government that determines how the spectrum will be divided for each user and use, and what types of equipment and technologies will be allowed for use in each block of spectrum. The government also grants the licenses that assigns the available shannels to an applicant for use. Finally, the government is also responsible for monitoring the usage of the airwaves.

"Regulatory decisions and not market forces are capable of deciding what is best for the public."[106] It is this mindset that resulted directly from the chaotic mess in broadcasting during the 1920s. The feeling was that without government supervision of the spectrum, users would interfere with one another and no one would be able to communicate. Today, the FCC continues to regulate the wireless spectrum with the same overly-conservative regulatory mindset that was originally devised in the late 1920s.

The initial regulation scheme attempted to guarantee that there was absolutely no interference with licensed channels. The FCC's model of regulation guarantees successful transmission through inefficient use of the spectrum.[107] In the curent model, two operators using the same channel are required to have a minimal physical distance between their transmitters. Additionally, there are mandated "guard bands" between adjacent frequencies that ensure no spillover. The buffered zones between channels and transmitters were determined based upon models using the worst

---

[105] Philip J. Weiser, and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 558.

[106] Ibid.

[107] Ibid., 559.

performance view of both transmitters and receivers. The regulation goal of the FCC was "that none of the signal - even at a fairly low power - of the undesired transmission would bleed into the adjacent channel."[108] Figure 4 represents a visual description of a primary channel with the adjacent guard bands as regulated by the FCC.

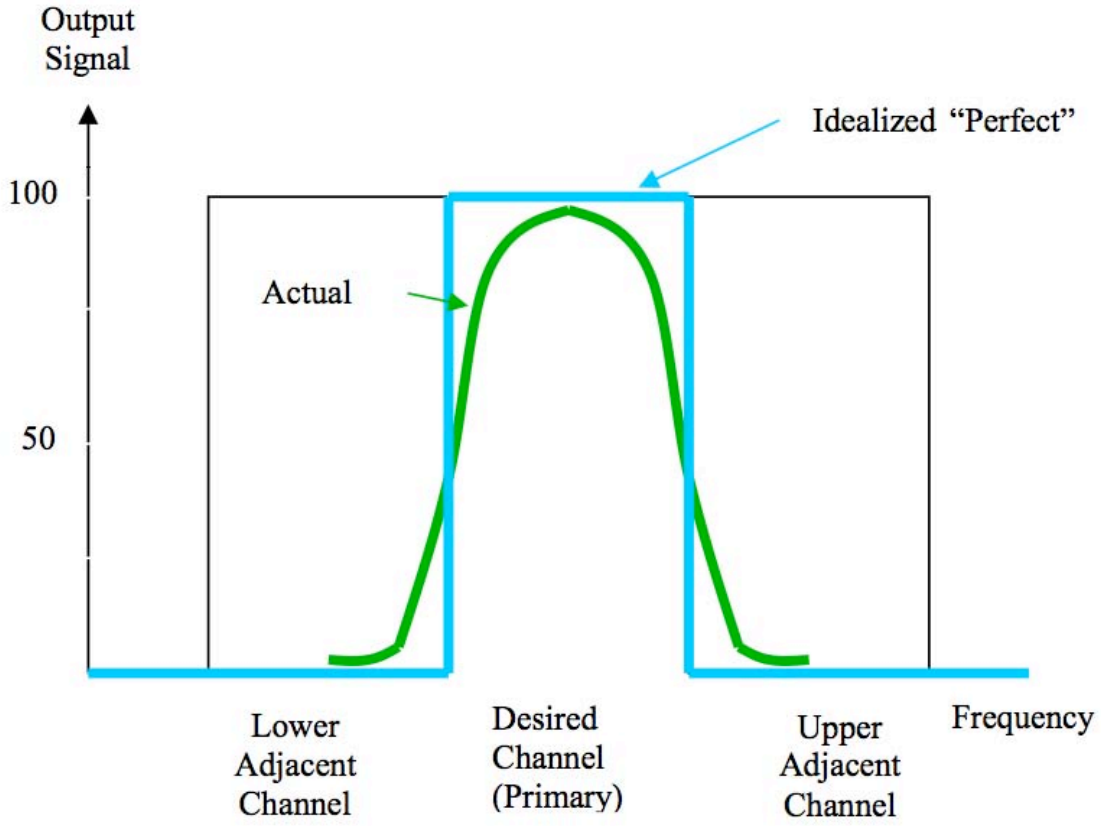

Figure 4. Ideal vs. Actual Spectrum Band[109]

The overly conservative view of regulation has allowed the government to successfully establish an effective wireless communications industry within the United States. However, the FCC continues to make regulation decisions in the same conservative manner originated in the 1920s. The FCC fails to modernize their regulation scheme as improvements are made within the industry. Better technology, knowledge, and modeling tools are available today that would improve the rules for

[108] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 560.

[109] Ibid.

spectrum regulation and make more efficient use of the spectrum. Weiser and Hatfield agree with Coase's assessment that an improved regulation scheme consisting of well-defined property-rights and low transaction costs will allow parties the bargaining tools to reach efficient outcomes. Spectrum regulation should ensure that gain from allowing additional interference more than offsets the harm it produces.[110]

b. Need for Reform

Numerous examples of FCC inflexibility exist but Weiser and Hatfield point to an egregious process and decision by the FCC as a prime example for why the current model needs change. Qualcomm attempted to create a new video service to mobile subscribers. The service might have interfered with adjacent services. Qualcomm offered the FCC a solution based on previous FCC guidance and requested permission to proceed. After twenty months, the FCC responded with a streamlined proposal for interference management deemed acceptable. Ultimately, the FCC never approved either solution, reverting back to their original policy that precludes all chances of interference.[111] "At present, the regulatory strategy for guarding against interference is notoriously undefined, moves too slowly to offer effective guidance, raises transactional costs (as well as entry barriers), and leads to underuse of the spectrum."[112]

2. Spectrum Regulation Model

Weiser and Hatfield challenge "the conventional wisdom that establishing spectrum property-rights is a fairly straightforward issue and can be managed along the lines outlined in the De Vany study."[113] The successes of the cellular bands are a good reason to shift towards a property-rights scheme, but they hesitantly point out that the characteristics for the successes may not be universally applied. Nonetheless,

---

[110] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 563.

[111] Ibid., 566.

[112] Ibid., 567.

[113] Ibid., 588.

> Despite the difficulties associated with establishing property rights in the space and frequency dimensions, the cases of television broadcasting and cellular telephone provide powerful precedents that when the FCC has established property rights in certain services, interference issues at the associated boundaries can be successfully resolved. Notably, valuable transactions involving the transfer of those rights take place on a routine basis, and affected parties work together to minimize interference. In cellular services, for example, the geographic spillover limit is the maximum signal strength permitted at the boundary and disputes over interference there are routinely solved without the involvement of the FCC.[114]

The technical properties of cellular bands are less prone to boundary variations in wave strength, therefore minimizing interference. The transmissions are cellularized and there are a small number of providers consistent across the majority of the regions, which promotes cooperative behavior amongst participants.

Weiser and Hatfield contend that an increased level of supervision would be required to implement a broader property-rights scheme for spectrum allocation. It is their contention that boundary disputes involving interference will not be adequately supervised and will lead to a loss of confidence in the markets. Interference must be avoided for any property-rights system to work.

> We are skeptical that this confidence will be borne out in numerous other contexts and think the uncertainty (or 'messiness') of geographic boundary rights caused by signal strength variations will make agreeing on reasonable agreements to avoid interference difficult. Instead, we believe that regular or occasional islands of interference across geographic boundaries that are tolerated today will become subject of litigation.[115]

Their proposed system requires the use of extensive computer modeling to ensure that interference disputes will be kept to an absolute minimum and that license holders are protected from frivolous lawsuits that may emerge because of the varying nature of wave propagation. "The FCC's inability to enforce property-rights could (1) effectively

---

[114] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 588.

[115] Ibid., 590.

undermine investment incentives and the development of new services, and (2) encourages self-help behavior whereby parties seek to make life difficult for one another to achieve business advantage."[116]

3. Predictive Modeling

Electromagnetic transmissions will act differently depending on the temperature, season, time of day, and weather conditions as noted previously. During the night, a transmission signal of the same strength will propagate further than it will during the day as is readily recognized by late-night listeners of the AM radio band. Weiser and Hatfield believe that because of this unpredictable behavior, one traditional model of trespass law cannot be applied across the entire spectrum. An oversight agency should model the maximum signal strengths at boundaries and not aim to avoid interference completely, but "maximize total utility in each band rather than to minimize interference to any spectrum user."[117] They endorse utilizing complex software modeling programs and using probability models of transmission behavior to create geographic boundaries to enhance a property-rights scheme of spectrum regulation. Although it cannot predict with 100% accuracy, a model can be generated to predict the behavior and broadcast market for transmitted signals in a geographic location. These predictive models should be verified and checked with real data in order to improve modeling fidelity and increase the accuracy of the models. The initial models may be on the conservative side but the monitoring will improve the modeling process to support the efficient use of the spectrum.

The scheme does not restrict the types of equipment but limits the level of the signal strength at the boundary, as proposed by De Vany. The only control the FCC would have over the license holder would be to set, monitor, and adjust the maximum signal strength allowed at the boundary.

---

[116] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 591.

[117] Ibid., 592.

The authors do not investigate the type of business models required in the implementation of their scheme. Before a property-rights regulation scheme could be implemented, further analysis would be needed to determine the best models to deploy in the different frequency ranges.

Weiser and Hatfield caution against the possibility of people purchasing rights only to catch people interfering with them in order to file lawsuits in court. This behavior is similar to what occurs in patent trolling. The authors believe that their predictive modeling technique will minimize, if not eliminate, this behavior in their proposed scheme.

D. THOMAS HAZLETT

Professor Thomas Hazlett currently serves as the Director of the Information Economy Project at George Mason Law School. He is a former Chief Economist at the FCC. Hazlett asserts that regulation leads to anti-consumer outcomes. He believes that exclusive property-rights will shift towards a competitive market.

The 2002 *Spectrum Policy Task Force* outlined three approaches towards spectrum regulation: exclusive-use, commons approach, and command-and-control.[118] The FCC normally follows the traditional command-and-control model and has shifted more towards the commons approach, through unlicensed bands, to spectrum allocation. Hazlett believes that the FCC has not adequately analyzed the potential value of spectrum in its decision to move towards the commons approach for spectrum allocation. He believes that the best method of spectrum allocation removes the bureaucratic process of allocation and leaves it to the free and competitive market to sort out spectrum allocation. In this way, decisions about the best use of the spectrum would be made by consumers based upon their needs rather than by a regulator.

> The FCC touts exclusive-use and commons as liberal alternatives to traditional regulation, for example, but it ignores the fact that the bureaucratic selection process it recommends constitutes command and

[118] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 69.

> control. Thus, some of the wireless market organization[s] are chosen - and others excluded - not by competitive market but by administrative allocation.[119]

1. Misguided Regulation

The current FCC policies aimed towards improving the spectrum allocation process fail to take full advantage of the spectrum market.. The decision makers define exclusive-use while excluding certain activities from exclusive-use, which is a contradiction of the definition. Exclusive-use will be the most efficient use of spectrum in most cases. Property-rights eliminate the barriers to productive use of the spectrum. Without those barriers, society will not have to wait for the government to make decisions. Eliminating the regulation barriers leads directly to competition and innovation.[120]

The FCC's shift towards the commons approach for spectrum regulation is not based on an accurate study of the facts. Analysis of the policy reveals flaws: the government assumes that shared use is the best method without adequate analysis. There is no mechanism currently to determine the actual value of spectrum rights. Shifting towards a system of property-rights will allow for development of such a mechanism to determine the actual value of a given asset.

> It is easy to figure out how much additional acreage to expand Central Park would cost the city, or how much revenue it would generate by selling a portion of it. Without private property-rights, these values are concealed, and the government agency supplying the public park's amenities lacks the [criteria] necessary for efficient decision making.[121]

Initial market costs and decisions made by asset owners reveal the true costs and benefits, as well as an efficient organizational structure for wireless markets. Any regulation will impose limits on the capital market discovery process. Hazlett is not

---

[119] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 69.

[120] Ibid., 70.

[121] Ibid.

arguing completely against the commons approach. He is only pointing out that without property-rights, the government cannot accurately value the assets it is charged with managing. "[Establishing] property-rights doesn't preclude a commons approach - it rationalizes it."[122]

2. Property Definition

Four basic property regimes have emerged over the years. "Open access" allows exploitation without limit, "state property" limits the use through rules created by governments, "commons property" limits the use through rules created by a group of owners, and "private property" allows for rules crafted by a single user.[123]

The current form of regulation in the United States, and almost everywhere else, can be described best as "state property." The public-interest regulations result in decisions that squander possibilities for more effective airwave utilization. "A given set of state-property rules blocks alternative property regimes from governing the airwaves, and these would yield valuable opportunities as well."[124] Hazlet states that the current form of regulation that aims to eliminate interference needs to be replaced by a more efficient system. "Potential conflicts are a byproduct of productive airwave use; efficient rules maximize the total value of wireless applications rather than minimize disruptions."[125]

Critics of property-rights point to the level of investment in WiFi technology as an example of the success of unlicensed spectrum. Investment in cellular technologies is double the amount invested in WiFi and consumers spend $8 billion annually, way more than WiFi. Using that argument, television would be seen as a triumph for regulation by the FCC. However, look at what the television spectrum is actually worth.

---

[122] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 70.

[123] Ibid.

[124] Ibid.

[125] Ibid., 71.

> Government planners set aside bandwidth with very high value for an over-the-air delivery platform that nearly 90 percent of U.S. households pay to bypass via cable or satellite. Given the incremental cost of moving to 100 percent cable and satellite distribution for broadcast TV content is on the order of just $3 billion, whereas the social value of the 402 MHz now walled off for broadcast TV service is likely to exceed $2 trillion.[126]

Using this argument, Hazlett deduces that the FCC's analysis shows the commons approach to spectrum regulation as being optimal is flawed.

The state-property regime dissipates spectrum value. If we used a more efficient model for spectrum use, we could have all the benefits of television and take advantage of the high value of wasted spectrum in the television broadcast spectrum.

The FCC feels that it should allocate more spectrum for unlicensed use. The government feels that it has been a success and, therefore, it is the best use of the spectrum. This line of thought also shows that more allocation of spectrum for television broadcast, since there are 2.7 televisions per household in America, would be wise. However, Hazlett's statement above shows that the FCC is blocking off $2 trillion worth of spectrum band for inefficient allocation to broadcast television. The FCC's approach to incremental unlicensed allocations lacks the needed multilayered analysis.[127] Just because you have determined one set of frequencies to be valuable, it does not imply the same gains from additional bandwidth.

3. Call for Property-rights

Hazlett calls on policy makers to identify and move towards property-rights alternatives for spectrum allocation. The competitive market forces should search, test, and reveal a variety of alternatives and gauge their value. Hazlett highlights that the call for property-rights is even proposed by two people at the FCC, Evan Kwerel and John Williams.

---

[126] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 71.

[127] Ibid.

> Kwerel and Williams note, 'Future expansion of dedicated spectrum for unlicensed use could be obtained through negotiation between the manufacturers of such devices and spectrum licensees… Competition between licensees would ensure that fees reflect the opportunity cost of the spectrum. Alternatively, manufacturers of low power devices might form a bidding consortium to acquire additional spectrum in our auction. If there is a continued desire as a matter of public policy to provide for such services on a free basis, the FCC itself might purchase the spectrum in auction, essentially reducing overall proceeds to the Treasury. This would have the advantage of making the opportunity cost of such allocations more explicit.'[128]

The consensus among economists is that a liberal ownership regime eliminates the barriers to competition that the current regime imposes. Hazlett proposes to allow owners, suppliers, consumers, and providers to make rational economic decisions that satisfy the consumer demands. While the current organization of the wireless markets may not be the most effective, "…trial and error of the market is a reliable mechanism to test alternatives."[129] This suggests the government, with a regulatory mindset, may not be the most able to provide a "commons" approach for consumer use.

a. Creation of Nextel

Hazlett uses the description of the creation of Nextel as an example of what can be created through market forces when restrictions are lifted. Forty years ago, the FCC allocated a 19 MHz band of specialized mobile radio (SMR) licenses from the 800 MHz cellular bands in every market. In the 1980s a former FCC lawyer began purchasing SMR licenses and acquired 40,000 licenses to form one nationwide network. He requested that the FCC remove limitations on the intended use of the bandwidth and the FCC approved. According to market costs, he determined that the bands could be used for both SMR services and cellular telephone. He transformed non-revenue-

[128] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 72.

[129] Ibid.

generating spectrum into 16 million subscriptions and sold it in 2005 for $35 billion.[130] "Markets are quite effective in discovering how to achieve efficient transactions."[131]

Liberalizing the spectrum will clear the way for future companies to produce innovative concepts using that spectrum. Liberalization of the spectrum empowers experimentation with alternative technologies and allows for the government to determine which forms of spectrum access need to be subsidized, just like a public park.

b. Proposed Experiment

Hazlett proposes that the FCC release a small piece of the overall spectrum to different users to determine the feasibility of property-rights and to collect free market data about the value of the electromagnetic spectrum.

> If the 402 MHz TV band could be divvied into five nationwide overlay licenses of approximately 80 MHz each and then sold at auction, five rival spectrum-sharing plans would emerge. Rationalization of the TV band, including rechanneling of TV stations, would expand wireless opportunities and unleash new technologies, services, and networks. Consumers, vendors, application suppliers, content owners, and investors would reward those creating the greatest value. Nothing requires a decade of rule making. To sacrifice the social gains of this exclusive ownership path is to incur another tragedy of the anti-market.[132]

E. REAL WORLD IMPLEMENTATION OF LIBERALIZED SPECTRUM ALLOCATION POLICIES IN EL SALVADOR AND GUATEMALA

Economists embrace the idea for wireless licenses but the underlying resource, radio spectrum, continues to be allocated administratively in most of the world. Sweeping telecommunications reforms occurred in El Salvador and Guatemala. Guatemala instituted their drastic spectrum policy reforms in 1996 and El Salvador adopted their new policy in 1997.

---

[130] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 73.

[131] Ibid.

[132] Ibid., 74.

The policies implemented in Guatemala and El Salvador are important because the spectrum liberalization proposals of the last forty years can finally be discussed in light of the results obtained from the wireless spectrum markets of Guatemala and El Salvador. Spectrum is a fertile field for economic analysis and it is economically important. The liberalization of El Salvador's and Guatemala's spectrum allocation policies allow us to analyze empirical results and discuss the benefits and pitfalls associated with the actual transition by governments towards liberal spectrum allocation policies.

1. El Salvador

The country of El Salvador passed two significant legal reforms to its telecommunications in 1996. First, they established a regulatory body, the General Superintendent of Electricity and Telecommunications (SIGET). Second, the laws reformed telecommunications, privatized the state-run telecommunications monopoly, Antel, and introduced competition into the mobile telephony market.[133] In El Salvador, license limitations were eliminated and interference concessions formed the constraints imposed by operators. Concessions represent the license to operate under El Salvador's new spectrum allocation scheme.

Requests for new concessions are reviewed for approval by a regulator. Concessions are not privately owned; however, "liberalization is achieved by a statutory provision permitting license holders full flexibility in the use of allocated frequencies."[134] The concession allows for leasing a band of spectrum, where the government retains ownership, but grants the concession-holder full flexibility to modify and sub-divide their asset.

[133] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 445.

[134] Ibid., 446.

a. The Elements of El Salvadorian Reform

The SIGET monitors the spectrum and other activities to detect and limit illegal use of the spectrum. SIGET operators are usually passive. The SIGET processes complaints and petitions that are brought to them by concession holders.

(1) Categories of Use. The reforms in El Salvador identified three general use categories: official use, free use, and regulated or commercial use.[135] Official use is reserved for government agencies or set aside by international treaties. Users must receive authorization to use this spectrum. Free use is a small amount of spectrum set aside for the general public to use. Regulated or commercial use provides for the most liberal set of rules. Government issued concessions are required to operate in these bands.

(2) Application Process. There is a six-step process in El Salvador for new users to procure a concession: 1) A new user petitions the SIGET for the right to a concession. 2) The SIGET considers the application. The application can be immediately rejected by the SIGET if the requested spectrum is already in use, there is no requirement to possess a concession for broadcasting in the requested spectrum, the applicant has previous violations of telecommunications law, or the applicant is not eligible to own a concession. 3) Once the request is deemed as valid, the SIGET publishes the request for a concession. All other parties, who deem the request might cause interference, have twenty days to challenge a license request to the SIGET. 4) Within ten days, the SIGET must hold a hearing for all parties involved in a concession request. 5) During the waiting period, the SIGET's Manager of Telecommunications performs a technical evaluation of the concession application. 6) The concession is granted with Manager of Telecommunications approval. If there are multiple requests for the same concession, the SIGET will auction the concession within sixty days.

(3) Annual Fee. The Telecommunications law stipulates that an annual fee is required in order to maintain a concession. According to the law, a base

[135] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 447.

rate is determined by multiplying the bandwidth by the transmission power, multiplied by a service factor. The service factor is determined by the position of the concession within the spectrum band.[136]

(4) Dispute Process. The telecommunications laws do not specify a formal complaint process. The SIGET is the authority for handling all disputes. Under their new laws, illegal electromagnetic transmission is considered a serious infraction and daily fines can be imposed. There are very few reports of signal interference following the reforms in El Salvador.[137]

2. Guatemala

In 1996, Guatemala established sweeping reforms in their spectrum allocation policy with the passage of the *Ley General de Telecommunicaciones*. Prior to this, there were two separate office that managed spectrum policies. One office regulated the spectrum below 800 MHz and another office made the decisions for the spectrum above 800 MHz. These licenses were free of charge and the demand for licenses far outweighed the supply. A black market arose where bribery and side payments were required to obtain licenses.

The new policy allowed for radio waves to be available for the use of those who requested them for a stated purpose. "The basic building block of Guatemala's approach to spectrum is that all spectrum not currently assigned to users can be requested by any person."[138] The government issues usufractory rights for spectrum use. In usufractory rights,

> holders exercise exclusive rights of the radio spectrum in question. This includes the right to change spectrum use over time, and to subdivide and transfer rights, subject only to minimal technical limitations, international agreements to which Guatemala is a signatory, and consistency with

[136] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 448.

[137] Ibid., 468.

[138] Ibid., 442.

> general frequency allocations established by the International Telecommunications Union for the Americas.[139]

The licenses in Guatemala are issued as *Titulos de Usufructo Frequencia* (TUF), which may be leased, sold, subdivided, or consolidated for a period of fifteen years. The spectrum can be used as the holder of the TUF wants. In the United States, the regulatory agency dictates the specific technology that can be used in a given spectrum; "a market for radio spectrum is excluded by regulatory restrictions. In contrast, Guatemala's reforms enable such a market to emerge."[140]

a. The Elements of Guatemalan Reform

The following section highlights key aspects of the Guatemalan allocation structure.

(1) Superintendent of Telecommunicationes (SIT). The SIT is the administrator to enforce specific rules. "The SIT is empowered to respond to private claims for spectrum access, and to adjudicate disputes over airwave rights. It may also engage in related activities, such as spectrum monitoring."[141] It should be noted that the SIT is susceptible to political pressure.

(2) Titulo Usufructo de Frequencia (TUF). A Guatemalan TUF contains six basic variables: frequency, hour of operation, maximum transmitted power, maximum power emitted at the border of adjacent frequencies, geographic territory, and the duration of the right.[142] Existing commercial users received TUFs and two other categories of users were created: government use and amateur authorizations. A TUF may be employed however the owner wants so long as the technical parameters of the TUF are obeyed.

---

[139] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 442.

[140] Ibid., 443.

[141] Ibid.

[142] Ibid., 444.

(3) Application Process. The application process for a TUF in Guatemala is a seven step process: 1) An applicant applies to the SIT for the right to use a frequency band under the TUF. 2) The SIT has three days to accept, reject, or declare the application incomplete. 3) If the application is accepted, a public notification is issued. Anyone opposed to the issuance may file a formal complaint. 4) The SIT adjudicates the validity of the complaints within ten days. 5) If the SIT declares the application valid, all interested parties are allowed to file claims for the TUF. 6) If there are no competing claims for the TUF, the petitioner receives the right for free. 7) If there are competing claims, an auction is held within thirty-five days and the TUF is issued to the highest bidder.

(4) Dispute Process (For Interference Complaints). TUF holders submit a formal complaint, with accompanied technical report, to the SIT in the event of a dispute regarding a TUF. The SIT then will notify the accused party that an interference complaint has been filed against them. The accused party then has ten days to file a technical report in response to the accusations against them. The SIT will then issue a decision within ten days resolving the dispute. If there is a ruling of fault, the party at fault has five days to cease transmission and pay appropriate fines.[143]

There are very few reports of signal interference. However, Guatemala has an issue with unauthorized broadcast by religious groups in the FM spectrum. The organizations claim they have the freedom to transmit without restrictions imposed by the government. The courts have agreed with the groups. Guatemalan law constrains the regulators and there is lack of confidence in the SIT to handle disputes.[144]

3. Analysis of Real World Performance

Analyzing Guatemala's and El Salvador's performance in the wireless industry provides an opportunity to examine the results of property-rights as a basis for spectrum

[143] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 466.

[144] Ibid., 468.

allocation. Thomas Hazlett attempts to prove that the application of property-rights in allocating spectrum results in an increase in available spectrum to mobile carriers, more competition amongst carriers, lower retail prices for mobile phone services, and an increase in mobile phone output.

The analysis compares data from the sixteen Latin American countries between 2000 and 2004. Hazlett's analysis "indicate[s] that liberal spectrum policies are positively related to increased spectrum deployment by mobile carriers and to increased competition (lower industry concentration) among them. Spectrum liberalization is also positively related to output in the mobile telephony sector (minutes of use) and with lower retail prices."[145]

a. Spectrum Use

Figure 5 compares the amount of spectrum utilized versus the Gross Domestic Product (GDP) of the country.

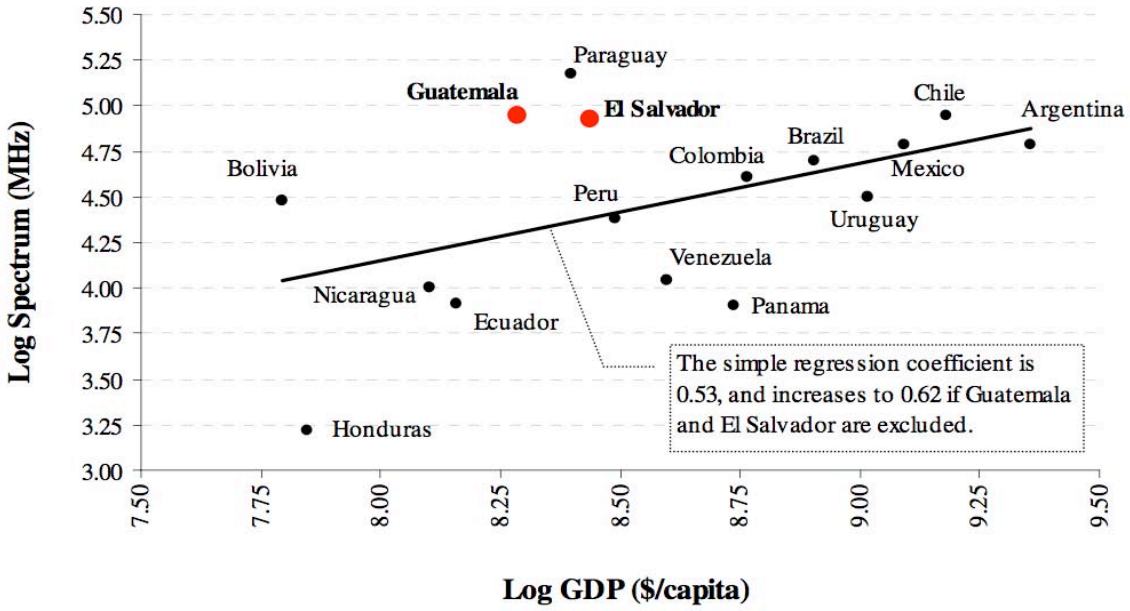

Figure 5. Spectrum Utilization in Central America[146]

[145] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 452.

[146] Ibid., 452.

The second graph, below, in figure 6 displays the results of the amount of spectrum used per thousand dollars of GDP. It shows that the liberalization policies in Guatemala and El Salvador have led to more use of the electromagnetic spectrum.

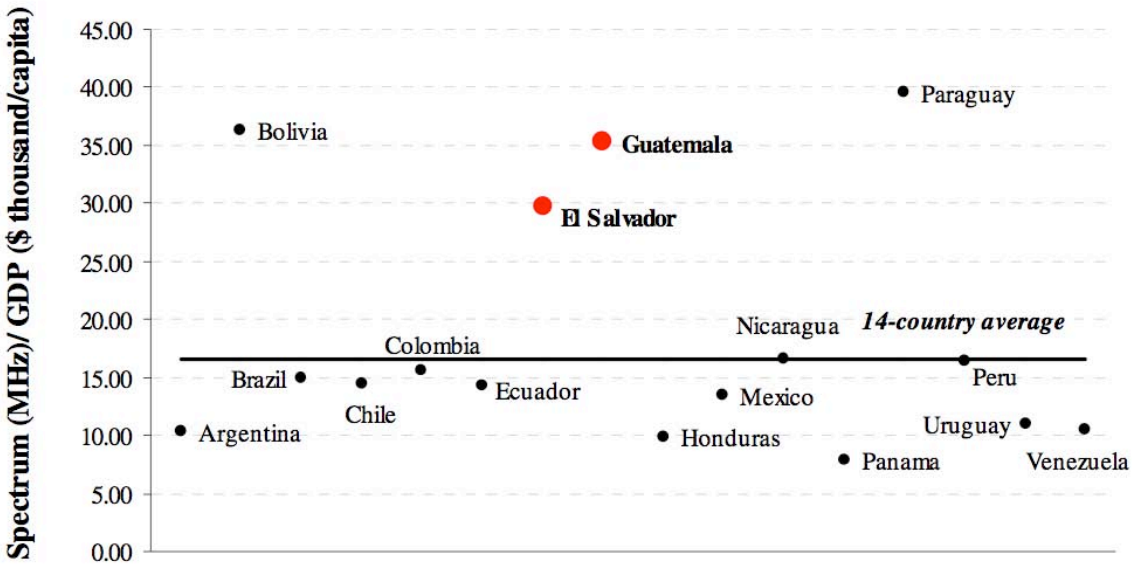

Figure 6. Spectrum Utilization vs. GDP in Central America[147]

Hazlett's statistical analysis of spectrum use determines that, "spectrum liberalization on average increases the bandwidth available to mobile networks by 16.02 MHz per $thousand GDP per capita" and that "the evidence then supports the hypothesis that liberal property rules are associated with greater bandwidth being made available."[148]

b. Competition

In order to calculate the effects of liberalization on competition in the Latin American market, Hazlett calculates the Herfindahl-Hirschman Indices (HHI) as computed from shares of mobile telephone revenues. HHI is a commonly accepted measure of market concentration. The HHI increases as the number of firms in the

[147] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 453.

[148] Ibid., 457.

market decreases.[149] Hazlett infers that the number of firms in the communications market can be directly related to the amount of competition. The HHI of all sixteen Latin Americas is displayed in figure 7. A lower HHI value indicates markets with more competition. The low HHI values for Guatemala and El Salvador indicate that their wireless communications markets have higher levels of competition.

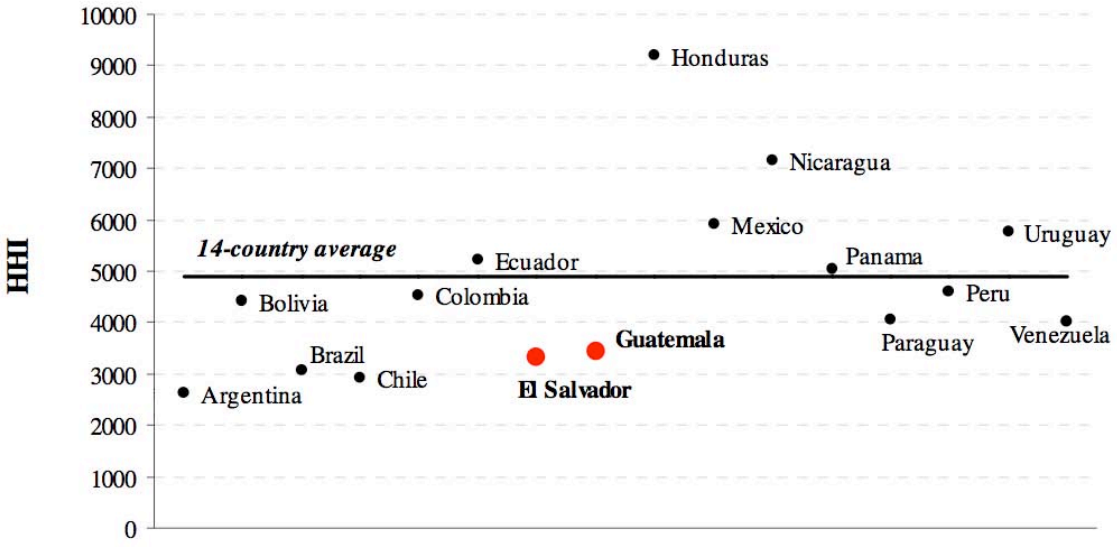

Figure 7. Measure of Competition in Latin American Wireless Communications Market[150]

The graph shows that Guatemala and El Salvador have relatively low HHI against all other Latin American nations. "Liberalization decreases HHI."[151]

[149] United States Department of Justice and the Federal Communications Commission. *Horizontal Merger Guidelines*. 8 April 1997: 15.

[150] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 458.

[151] Ibid., 459.

c. Price

The results of the analysis for price fail to provide conclusive results about the effects of liberalization on the associated costs in the marketplace. Data used for the calculations in this analysis shows a statistically insignificant increase or decrease associated with the average.

d. Output

Output is analyzed by looking at the total minutes of use (MOU) per person. The graph, shown in figure 8, shows the results of the MOU per $thousand GDP per capita.

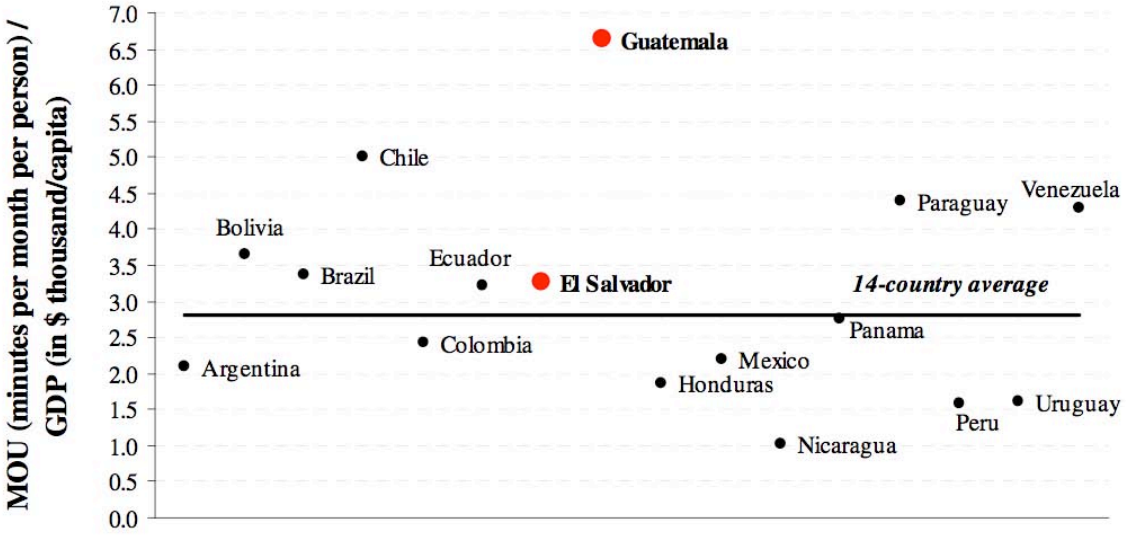

Figure 8. Wireless Use vs. GDP in Central America[152]

"Dividing the MOU per person by GDP per capita, we can see that Guatemala is significantly and El Salvador is slightly above the 14-country average."[153] This result shows that liberalization of the cellular telephone markets in Guatemala and El Salvador have led to an increased number of minutes of use per capita. The results are statistically

[152] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 463.

[153] Ibid.

significant and point directly to the fact that the liberalized policies have improved the wireless communications market to benefit the consumer.

e. Summary of Results

Results of the analysis of the performance of spectrum allocation in the Guatemalan and El Salvadorian marketplace showed statistically important results. According to the analysis, liberalization in the spectrum allocation policies of Guatemala and El Salvador resulted in increases in spectrum use, competition, and output. "The empirical evidence gleaned from mobile telephone markets, while preliminary, broadly supports the Coasean conjecture that decentralized property-rights were relatively efficient mechanisms for policing spectrum resource use."[154]

The limited data supplied by Guatemala and El Salvador suggest that there are economic benefits for liberal spectrum policies. "We find that private spectrum rights yields wireless phone markets that perform relatively efficiently, in terms of outputs and prices, suggesting consumer welfare gains from liberalization."[155]

F. DEREGULATION

Before proposing an allocation scheme for spectrum, it is important to take a look at some lessons learned in relaxing the regulations in other industries. This section highlights the benefits of regulation as well as some possible pitfalls in implementing new policies. The final part of this section presents a set of guidelines for creating and establishing a thriving industry with minimal restrictions.

"Since the 1970s, deregulation has succeeded in increasing overall economic welfare and sharply reducing prices, generally by about 30 percent, for transportation - including air travel, rail transportation, and trucking - and for natural gas and

[154] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 464.

[155] Ibid.

telecommunications [in the United States]."[156] However, it seems that there are an equal number of successes and pathetic failures when it comes to deregulation. There have been successes in the airline, railroad, and northeastern electricity industries. Deregulating the California electric industry was a failure. It resulted in "locking-in" higher consumer rates for ten years. In the telecommunications industry, the Telecommunications Act of 1996 cost millions of dollars in lobbying and litigation and resulted in an unimproved marketplace for consumers.[157]

Although the results are not always as intended, "a wider assault against myriad forms of inefficient government markets - beyond classic 'regulation' - is more urgently needed."[158] The successful implementation of a deregulation scheme requires an understanding of what conditions lead to success and what leads to failure. The government should reduce interference in markets, including spectrum allocation, and focus on maximizing the value of the assets on the open market.

1. Benefits of Deregulation

Success in regulation is achieved by maximizing the utility or welfare. There are two benchmarks to use in determining success in deregulation. First, compare the current condition of the industry to the state of the industry before deregulation. Second, ask "what would the current state of the industry be if deregulation had been blocked?" Just about every deregulated industry has seen increased efficiency and improved quality of service.

> In virtually every deregulated industry, there have been substantial gains in efficiency. The firms supplying the service - new entrants and incumbents alike - produce it at costs about 30 percent lower than would have been incurred under the old regulatory regime. In addition, service quality tends to improve. Deregulation reduced airline fares, trucking costs, and railroad transportation costs by about $35 billion per year (in

[156] Robert W. Crandall. "Extending Deregulation: Make the U.S. Economy More Efficient." *Opportunity* '08. Washington, D.C.: The Brookings Institution, 2007: 1.

[157] Eugene Bardach. "Why Deregulation Succeeds or Fails." *Creating Competitive Markets: The Politics of Regulatory Reform.* Ed. Marc Landy, Martin Levin, and Martin Shapiro. Washington D.C.: The Brookings Institution. 2007: 333-335.

[158] Crandall. "Extending Deregulation: Make the U.S. Economy More Efficient." 2.

> 1995 dollars), largely through improvements in efficiency. Similarly, reductions in long-distance telephone rates came about because of improved efficiency and the FCCs more efficient pricing of interstate carrier access, not from reduced telephone company profits.[159]

Table 4 illustrates the results achieved through deregulating several industries.

Sector	Nature of Deregulation	Consumer Benefits
Airlines	Total	33% reduction in real fares
Trucking	Total	35-75% reduction in real rates
Railroads	Partial; rate ceilings and floors on "monopoly" routes	More than 50% decline in real rates
Natural Gas	Partial; distribution still regulated	30% decline in consumer prices
Telecommunications	Partial; local rates and interstate access still regulated	More than 50% decline in long distance rates
Banking	Consumer rates deregulated; entry liberalized	Increased interest on consumer deposits; improved productivity

Table 4. Effects of Deregulation[160]

a. Industries that Remain Regulated

Numerous government sectors of private industry remain under some government control of prices and output. The housing industry retains certain rent controls. Government heavily subsidizes mortgage financing. The agriculture industry contains price supports and marketing agreements. Imported metals and chemicals are still governed by the 1974 Trade Act. Highways and roads are supported by provisions; health care fees are regulated; and the government still controls a large share of the valuable electromagnetic spectrum.[161]

---

[159] Robert W. Crandall. "Extending Deregulation: Make the U.S. Economy More Efficient." *Opportunity* '08. Washington, D.C.: The Brookings Institution, 2007: 3.

[160] Ibid., 4.

[161] Ibid.

b. Industries Needing Reform

The most important sectors that remain under government regulations are telecommunications, electricity, and air transportation.

(1) Telecommunications. Although cellular markets and voice-over-IP (VOIP) services have introduced more competition into the phone markets, the FCC continues to provisison access to local and small business customers. They essentially control the pricing policies for local and long distance coverage. Full deregulation in the telecommunications industry would minimize the barriers to both entry and investment into the telecommunications industry. Full deregulation could result in $7 billion savings per year to the customers with the elimination of inefficient pricing of local and long distance services.[162]

(2) Internet. With the increasing amount of services provided over the internet, additional investment is required to keep up with the expanding traffic loads. Government imposed "Network neutrality" eliminates tiered pricing schemes in providing internet access. Any policy governing internet pricing schemes would be premature and counterproductive. There are enough Internet Service Providers (ISP) in the marketplace that one company cannot exploit the market through discriminatory pricing policies.

(3) Electricity. The generation of electricity has been greatly deregulated and the market is competitive; however, transmission and distribution of electrical power remain as monopolies. Deregulation of the electric industry could result in similar increases in competition as the telecommunications industry has seen.

Robert Crandall warns about careful implementation of future attempts to deregulate the electric industry. California's attempt to deregulate their electric industry resulted in an additional $12 billion annual increase in costs to the consumer.[163] He urges caution when creating a deregulated electricity market, but

---

[162] Robert W. Crandall. "Extending Deregulation: Make the U.S. Economy More Efficient." *Opportunity* '08. Washington, D.C.: The Brookings Institution, 2007: 7.

[163] Ibid., 10.

believes that an increased number of small scale providers and increased generation could prove to be beneficial to the customers. However, a successful deregulation of the electric industry will require vast investment in transmission capability.

(4) Air Transportation. Regulations in the air transportation industry continue to place restrictions on domestic carriers abroad and unnecessary restrictions on foreign carriers domestically. These regulations block increased competition in the markets. The federal government manages the air traffic control system in the United States. There are large potential gains in liberalizing policies across the air transportation industry.

(5) Electromagnetic Spectrum. "While few regulated industries remain to be deregulated, federal and state government policies affect prices of a number of resources and could be relaxed or at least reformed."[164] Recently spectrum rights have been auctioned off for commercial purposes, but this represents only a small portion of the available spectrum. "The potential gains from freeing the remaining spectrum from government management - particularly that set aside for defense, public safety, and broadcasting - are extremely large. Were this spectrum allocated through market mechanisms, substantial economic value could be created."[165] The 400 MHz television bands could produce a net gain of $8 billion in higher valued use. "A total shift to a market allocation of spectrum would obviously unleash enormous value."[166]

2. Discussion of Deregulation

"Deregulation and market design are such complex and multifaceted exercises that their success or failure clearly depends on multiple factors."[167]

---

[164] Robert W. Crandall. "Extending Deregulation: Make the U.S. Economy More Efficient." *Opportunity* '08. Washington, D.C.: The Brookings Institution, 2007: 12.

[165] Ibid.

[166] Ibid., 13.

[167] Eugene Bardach. "Why Deregulation Succeeds or Fails." *Creating Competitive Markets: The Politics of Regulatory Reform*. Ed. Marc Landy, Martin Levin, and Martin Shapiro. Washington D.C.: The Brookings Institution. 2007: 336.

a. Characteristics of Failed Deregulation

Eugene Bardach identifies the characteristics of failed deregulation policies in his paper, "Why Deregulation Succeeds or Fails." He identifies four distinct characteristics of flawed policies: protectionism, crowded and prolonged process, ideological incompetence, and avoiding blame.

Protectionism in deregulation involves the prior regulating agence not participating towards achieving the goal of a deregulated market. Bardach describes it as the "government protecting its own market competition, arguably to the detriment of the public."[168]

Deregulated markets require a varying need for secondary regulation or phase-two regulation. This is caused from issues being inadequately defined in the initial deregulation scheme: ambiguous or imcomplete property-rights, residual natural monopolies, externalities, and information asymmetries.[169] "However benign the motivation, the longer that second phase intervention continues, the longer it remains a target for rent seeking and other such distorting forces."[170] Good design and luck minimize the amount of handholds required to complete thed deregulation process. Handholds, or additional regulations, increases the likelihood that complete deregulation will stall.[171]

Decisions by the regulators can doom the deregulation efforts. In the British pension reform, a combination of the implemented policies and additional tax incentives combined to produce negative market results. Eventually, it resulted in a more regulated industry than existed at the beginning of the process. The Canadien Radio and Telecommunications Commission incompetently installed price floors for the

[168] Eugene Bardach. "Why Deregulation Succeeds or Fails." *Creating Competitive Markets: The Politics of Regulatory Reform.* Ed. Marc Landy, Martin Levin, and Martin Shapiro. Washington D.C.: The Brookings Institution. 2007: 336.

[169] Ibid.

[170] Ibid., 337.

[171] Ibid.

implementation of VoIP service. The focus should have been placed on forcing prices downward. This resulted in failed deregulation.[172]

b. Practical Implementation of Deregulation

The most harmful condition to implementing deregulated policies is the government having a high stake in the success or failure in the deregulation effort. "There may be at least four ways in which this condition can be avoided, minimized, or at least managed: shrink or neutralize the bureaucracy, absorb moral casualties, get most of it right the first time, and create countervailling constituencies."[173]

(1) Shrinking or Neutralizing the Bureaucracy. Effective deregulation requires destroying the bureaucratic niches. This "limits the capacity of important government stakeholders to intervene detrimentally in phase-two politics."[174]

(2) Absorbing Moral Casualties. Removing regulations is not beneficial to all parties involved. Deregulation, typically, has winners and losers. "The government's desire to buffer the deserving victims of deregulatory transitions is morally admirable as well as politically prudent. But the buffering policies typically create opportunities for meddling of all kinds, including the revival of rent seeking."[175] However, it may be necessary to implement some buffering policies as long as it does not affect the long term competitive pricing.

(3) Get It Right the First Time. Well-planned deregulation should aim to avoid the need to implement a second-phase of deregulation. The need for a second-phase can be minimized with well defined and planned implementation of deregulation policies. This is not an easy accomplishment with the number of uncertainties and complexities in the market.

---

[172] Eugene Bardach. "Why Deregulation Succeeds or Fails." *Creating Competitive Markets: The Politics of Regulatory Reform*. Ed. Marc Landy, Martin Levin, and Martin Shapiro. Washington D.C.: The Brookings Institution. 2007: 338.

[173] Ibid., 339.

[174] Ibid.

[175] Ibid.

(4) Creating Countervailing Constituencies. Government meddling in deregulation may not be possible to prevent. One way to counter the government's desire to get involved is to "create new constituencies to oppose it."[176] The ultimate goal would be to "create a set of investors and workers with a stake in pressuring the government 'not to renege on its deregulatory plans.'"[177]

c. Deregulation Success

The success of deregulation may hinge on the elimination of the two-phase problem where ineffective regulation leads to re-regulation efforts and eventually full regulated policies again.

> I am a little more confident of the proposition that when government or policymakers have high stakes in deregulation or intervening in phase-two markets, their actions often lead, directly or indirectly, to failure. This is not because the evidence is so rich or supportive but because the proposition is but an application of the more general theory that the process of government is vulnerable to a variety of hazards such as rent seeking, ideological zealotry, legalism, slow-paced bureaucracy, and the piling on of objectives and agendas.[178]

G. CHAPTER REVIEW

This chapter outlined some of the leading ideas about how to improve spectrum allocation. They all emphasize implementing property-rights to best allocate spectrum. The empirical evidence from establishing property-rights schemes in Guatemala and El Salvador supports implementing a market-based allocation scheme. The final part of this section detailed the benefits of removing unnecessary obstacles in other industries, the possible benefits of deregulating spectrum, and a blueprint for any deregulation policies.

---

[176] Eugene Bardach. "Why Deregulation Succeeds or Fails." *Creating Competitive Markets: The Politics of Regulatory Reform*. Ed. Marc Landy, Martin Levin, and Martin Shapiro. Washington D.C.: The Brookings Institution. 2007: 340.

[177] Ibid., 341.

[178] Ibid.

The next chapter builds on these ideas to propose an allocation scheme that takes advantage of liberalized regulation and sound principles for establishing a new spectrum allocation scheme.

V. LEASED RIGHTS IN SPECTRUM ALLOCATION

This chapter presents an allocation scheme that promotes innovation of more efficient use of the spectrum. First, the chapter defines the lease and the rights associated with the lease. The final two sections define the role of the administrative agency in implementing the scheme and the efficient dispute resolution process.

The most important factor in creating a successful spectrum allocation scheme is establishing clear definitions and rules associated with the allocated asset. In this case, analysis of the proposed time, area, and spectrum scheme of Arthur De Vany and the allocation systems implemented in Guatemala and El Salvador served as the foundation for the definition of rights in this proposal.

A. OVERVIEW OF THE ALLOCATION SCHEME

A system of leased rights retains the ownership of spectrum with the government and takes advantage of free-market forces to efficiently allocate spectrum. The current impasse in the spectrum allocation debate, between proponents of property-rights and the supporters of a regulation model, is a clear definition of what exactly is being allocated. It boils down to whether it is the ether through which transmissions occur or the right to transmit through that ether? This proposal eliminates the inhibitions associated with a property-rights scheme while unleashing the full benefits of the market to improve efficiency and innovation in wireless technologies by allocating spectrum leases.

B. LEASED RIGHTS

The lease is treated like property since possession of the lease allows for transfer of rights and sub-leasing of the associated portion of leased spectrum. It imposes no restrictions on the types of equipment that can be used or the transmitted power. Instead, it imposes a limit on the level of the signal that is measured at the geographic and spectral boundaries of the lease. The elimination of unnecessary restrictions on type of equipment and transmitter power results in better use of the allocated spectrum by leaseholders.

Characteristic	Specification
Time of Allowable Transmission	24 hour period
Geographic Area	National lease
Spectrum	27 separate 100 MHz frequency bands • Excludes government allocated and unlicensed bands • Leaseholder must honor previous agreements that are property of the lease
Lease Duration	15 year duration
Interference Protection	Maximum field strength measured at geographic and spectrum boundaries
Sub-Lease Agreements	• Time period may be modified • Geographic area may be modified as desired • Spectrum modifications may be made as long as all primary interference protection limits are observed • Secondary modifications are limited to fifteen years in duration • All secondary modifications must satisfy established limits of primary lease

Table 5. Spectrum Lease Properties

Table 5 illustrates the properties of each lease in this allocation scheme. Primary leases contain six operating characteristics that ensure orderly transmission continues in the commercially available bands of spectrum. Six factors provide exclusivity and outline the leaseholder's broadcast rules in order to provide for safe and orderly transmission. Each characteristic of the spectral lease is described in more detail in the following sections.

1. Leaseholder Rights

1) Leaseholder is granted flexible rights for fifteen years to a 100 MHz band of total spectrum. Available spectrum for immediate use excludes government allocated spectrum, established unlicensed bands, and previous modifications that are property of the lease.

2) Leaseholder has full flexibility to make sub-lease agreements within the primary time, area, and spectrum constraints of the lease.

3) Maximum length of sub-lease agreements shall not exceed fifteen years.

4) All sub-lease conditions are property of the lease and must be honored following the transfer of a lease.

5) Leases are for nationwide transmission within the spectrum band, subject to exclusion of areas where there is government allocated spectrum, unlicensed spectrum, or previous modification to the lease.

6) Interference protection is provided by establishing an acceptable maximum electromagnetic field strength for all transmissions at the geographic and spectral boundaries.

7) All secondary lease modifications will be recorded with the agency tasked with administrative oversight of this scheme.

The following sections provide the background for determining the parameters for this lease allocation scheme.

a. Time

Primary leases will specify the allowed broadcast time for the lease over the entire twenty-four hour period of the day. Allocating primary leases for the entire day provides the most flexibility to the leaseholder. Sub-lease agreements by the leaseholder may be made to divide their leased spectrum into smaller time allocations. All sub-lease conditions must be reported for accurate maintenance of the allocated leases; the collecting authority is discussed later in the chapter.

b. Geographic Area

Each lease identifies a location where transmission is authorized and in this scheme each primary license will be valid for the entire country. Initial broadcast area is subject to previous agreements in the lease as well as exclusion zones where the spectrum is allocated by the government or put aside for unlicensed use. In order to maximize the flexibility granted to the leaseholder, the area allocated to the primary leaseholder is maximized through a national lease. The lease provides full flexibility to the primary leaseholder to make any secondary modifications and provisions to divide the lease into smaller geographic areas. The ability for the leaseholders to modify their leases through open-market transactions will provide incentive for the leaseholder to make decisions that will maximize the value of their lease.

c. Spectrum Block

The electromagnetic spectrum between 300 MHz and 3 GHz encompasses 2,700 MHz of total spectrum available for allocation. This scheme allocates twenty-seven equal bands of 100 MHz total. Spectrum that is immediately available for use varies from lease to lease and is subject to all previous agreements and excludes NTIA allocated spectrum and unlicensed spectrum bands.

As of 2002, 438 MHz of the UHF spectrum was unencumbered and available for immediate restructuring and use.[179] On average, each 100 MHz block of leased spectrum would contain approximately 16% of the spectrum that is available for immediate employment.

The UHF frequency band provides ideal operating characteristics for current mobile services. In 1994, the FCC dedicated the spectrum between 1,850 MHz and 1,990 MHz for implementation of nationwide Personal Communication Services (PCS). Each block size contained 10-30 MHz.[180] Today's cutting edge mobile technologies are implemented using third-generation (3G) mobile services. Implementation of 3G requires 15-20 MHz of spectrum.[181] In this allocation scheme, the goal is to provide for 15-20 MHz of unallocated spectrum in each lease in order to be large enough to implement valuable technologies, but also small enough to take advantage of a competitive market. Since approximately 16% of the UHF band is available, leases of 100 MHz blocks of spectrum will provide, on average, 15-20 MHz of initially available spectrum. This scheme proposes allocation of twenty-seven exclusive frequency bands that excludes only the NTIA allocated spectrum and spectrum dedicated to unlicensed use in those bands. It follows the "Swiss cheese" model used in implementing PCS in the mid-1990s.[182]

Unlike in Kwerel and Williams' proposal, this scheme allows current exclusive rights use licensees to be granted the flexibility to make agreements with primary leaseholders for continued use. At the end of the current license, the license will be merged into the property of the primary lease. Eventually, the only exclusions to complete unencumbered spectrum available to the leaseholders in the UHF spectrum will

---

[179] Evan Kwerel and John Williams. "A Proposal for a Rapid Transition to Market Allocation of Spectrum." *Federal Communications Commission, OPP Working Paper Series* 38 (2002): 28.

[180] "Broadband PCS." *The Federal Communications Commission*. 28 October 2004.

[181] "Third Generation Wireless Systems." *The Federal Communications Commission*. 25 November 2002. 26 January 2009 <http://www.fcc.gov/3G/>.

[182] Evan Kwerel and John Williams. "A Proposal for a Rapid Transition to Market Allocation of Spectrum." 5.

be the frequencies used by the NTIA and unlicensed use. The idea of protecting the unlicensed spectrum is similar to the government allocation of property for public parks.

d. Lease Duration

Each primary lease will expire after a fifteen-year period and be re-allocated. Sub-lease agreements become the property of the lease, however any sub-lease agreement is limited to 15 years in duration. Future leaseholders must recognize previous agreements; but, by limiting the secondary duration agreements to fifteen years, it provides flexibility to the leaseholder to decide how to effectively allocate their entire piece of their leased spectrum.

Fifteen-year lease durations provide enough time for leaseholders to implement their desired technologies in order to take full advantage of the allocated spectrum band. Conversely, the fifteen-year period ensures continued competition in the market for the allocated leases. Constant competition for the primary leases provides the necessary incentives for leaseholders to best utilize their spectrum.

e. Maximum Power at the Boundary

Establishing limited electromagnetic field strength at both geographic and spectral boundaries provides interference protection. The allocated licenses in this scheme are nationwide and contain no geographic boundary with other leaseholder, but as explained later in this chapter, will have to obey previously granted or government protected rights within their lease. The level of transmission at the border may be modified according to the realistic broadcast environment. If interference levels are unacceptable, the level of acceptable field strength at the border may be modified through consensual agreement, administrative recommendation, or judicial order. By imposing transmission restrictions at the boundaries, it creates an orderly system for successful spectrum management while maintaining a minimal amount of enforcement costs.

f. Sub-lease Agreements

In order to maximize the potential market benefits for spectral allocation, the scheme must allow maximum flexibility to the leaseholder. Although it is not a property-rights proposal, the ability to make sub-lease agreements provides the leaseholder the same benefits as a property-rights scheme.

Along with the primary modifications as outlined above, the leaseholder may make arrangements to create a secondary level of spectrum allocation within their lease. The leaseholder is allowed to make agreements, within their leased spectrum, in the following characteristics of the lease: time of allowed transmission, geographic location, permitted frequency for transmission, duration of the agreement, and maximum field strength allowed at the secondary boundaries. All sub-lease conditions must satisfy the primary permissions of the lease.

In order to maintain a system of orderly broadcast, sub-lease modifications must be recorded with an agency to maintain a record of all agreements. Technical analysis of disputes and judicial review will be based upon the records maintained in the database. The accuracy of the database is essential in maintaining a chaos free broadcasting environment. A method of encouraging reporting would be necessary in order to ensure leaseholders keep the administrative body informed of the current conditions of their lease. All of the sub-lease agreements will be bound to the primary lease and must be honored by subsequent leaseholders should possession of the lease be transferred.

2. Lease Examples

This section provides two simplified examples of how the lease allocation scheme works. The leases are provided as examples and do not represent the current allocation of the spectrum bands they represent. Each lease consists of exactly 100 MHz of spectrum. The spectrum, at the beginning of the lease, is either encumbered or unencumbered. The unencumbered bands are available for immediate use. The encumbered spectrum has been allocated previously. Encumbered spectrum consists of two types of allocation:

government allocated spectrum, and spectrum that has been allocated and is under an existing agreement. As discussed in the previous section, all spectrum under previous agreement will become possession of the lease upon termination of the agreement and government allocated spectrum will remain under government possession.

a. Lease A

Figure 9 is a visual representation of a chunk of leased spectrum between 2300 and 2400 MHz.

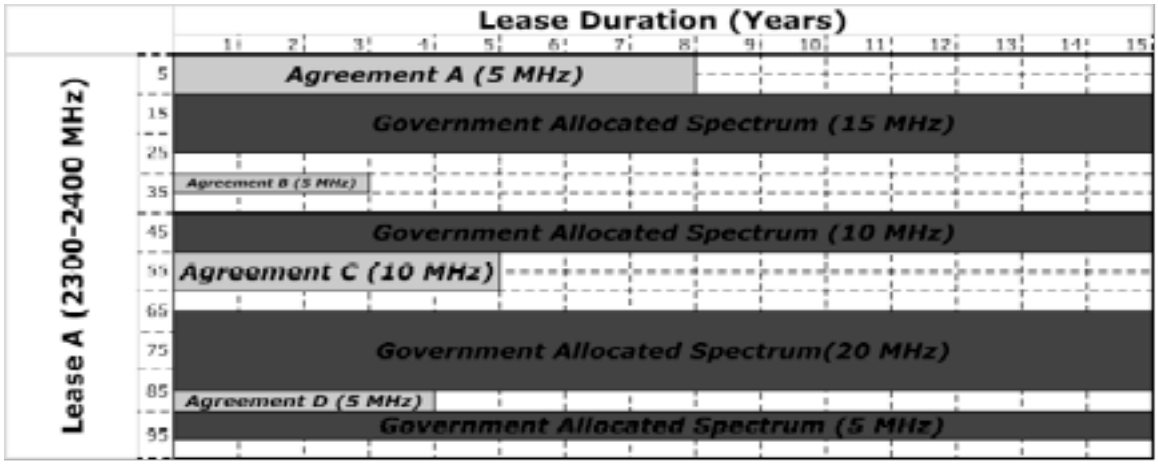

Figure 9. Example Lease A

There are four government-allocated bands and four commercially allocated bands. Initially, there is 25 MHz of unencumbered spectrum for immediate use. Within the first eight years, all previous agreements for commercially allocated spectrum will expire, providing 25 MHz of additional spectrum for use by the leaseholder. 50 MHz will remain allocated by the government, but by the end of the first lease cycle, lease A will provide the leaseholder with 50 MHz of spectrum for allocation however they wish.

b. Lease B

Figure 10 is a visual representation of a piece of leased spectrum between 2500 and 2600 MHz.

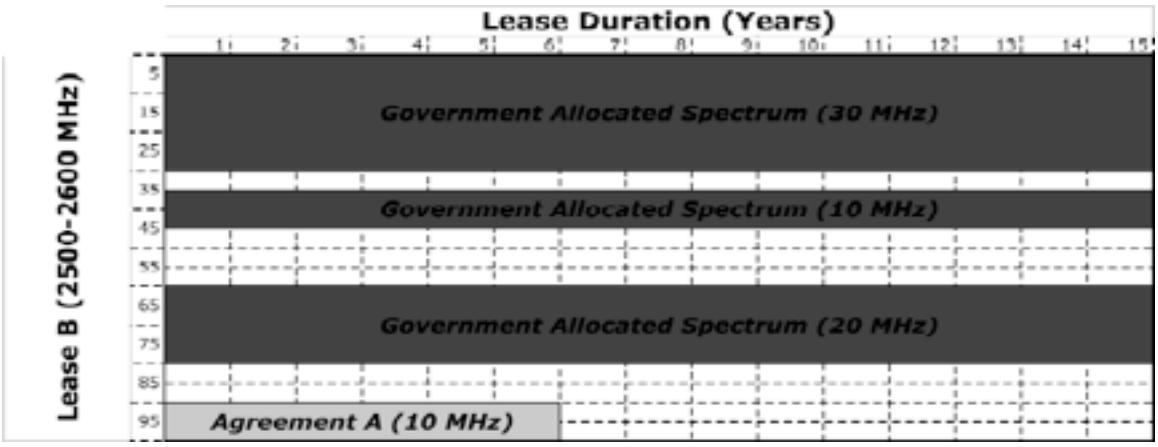

Figure 10. Example Lease B

Example lease B has three bands of government allocated spectrum, totaling 60 MHz. There is only one 10 MHz band allocated through previous commercial agreement. Initially, lease B provides more immediately available spectrum than lease A, but more of lease B is exempt from the lease because the government retains it. At the beginning of the lease, 30 MHz is available for immediate employment, but only 10 MHz becomes available over the duration of the lease. Although this band initially has more available spectrum available than lease A, by the end of the first lease cycle, lease B will only have 40 MHz of spectrum available, compared to 50 MHz available in lease A.

C. DEFINITION OF THE ADMINISTRATIVE SYSTEM

This system does not require a regulating body. It requires an administrative agency to implement and oversee the lease-rights. Additional responsibilities include technical and economic analysis of interference disputes and technical advisor to the Judicial System.

Use of the electromagnetic spectrum required strict regulation in the late 1920s in order to clean up a chaotic industry. However, the FCC has proven over the years to have inhibited innovations and create unnecessary barriers to new technologies. Although the 1996 Telecommunications Act attempted to eliminate the FCC's technology retardation problem, the FCC remains a bureaucratic system that creates unnecessary obstacles to new technologies in wireless communications.

Modern equipment and better technical knowledge make it possible to implement a system that loosens restrictions and creates an atmosphere that promotes investment and competition in the commercial spectrum. Former FCC Commissioner Harold Furchtgott-Roth, who was with the FCC during the implementation of the 1996 Telecommunications Act, claims that the current structure of the FCC does not allow it to adequately regulate effectively. This scheme does not require spectrum regulation but administrative oversight. It provides judicially backed enforcement power to issue economically and technically sound recommendations in interference disputes and a method of quick resolution to detrimental interference.

Lease-rights require an administrative system that is free of both bureaucratic limitations and political pressure. The FCC does not have a good track record at being able to promote efficiency in the use of the electromagnetic spectrum. The Telecommunications Act attempted to improve the performance of the FCC, but the established government agency has continued to hinder growth. For this scheme to work, a new administrative agency should be created without the bureaucratic issues and limitations of the current FCC.

1. Administrative Duties

There are five administrative duties required to implement this lease-rights system. A separate agency is required to implement the policies associated with the scheme and needs to be created. As Harold Furchtgott-Roth points out in his book, *A Tough Act to Follow?*, the FCC has too much power and cannot adequately perform all of its duties. Therefore, in order to adequately perform the required tasks, it is important to limit the responsibilities and authority of a new agency to an administrate role and to provide advice on matters of technology.

The first administrative duty is to create the leases to be allocated. There will be twenty-seven exclusive leases of equal 100 MHz blocks for the frequency band 300 MHz through 3 GHz. Efficient utilization of the leases will occur following allocation through consensual agreement amongst leaseholders. This system encourages maximum utility of the allocated spectrum.

Secondly, the agency is required to allocate the leases in its possession. This is not only for newly created leases, but also for defaulted and expired leases. The current auction system evolved following studies of game theory and through practical implementation.[183] The auction system is devised so it is fair to every one involved. There was no evidence discovered in researching this project that provided any type of conclusive evidence that the auction system is flawed. Therefore, it would also serve as an excellent allocation tool in any new scheme.

The rollout of this allocation scheme must maintain continuity of service. The unassigned spectrum will be released into the market through an orderly lease distribution auction process. A ten-year process for allocating the twenty-seven bands maintains the current level of operability while infusing the leased spectrum. It also establishes an annual cycle of two to three primary license auctions. Defaulted licenses will be auctioned off within one year of default collection and each primary license will be auctioned three years prior to expiration of the lease to allow for winning leaseholders to transition into the responsibilities as the primary leaseholder and for those losing their lease to execute contingency plans for losing their lease.

A major responsibility of the administrative agency is to collect the annual tariffs associated with the lease. The annual tariff is the amount of the winning bid over the period of the lease. The collected income serves as both operating revenue for the administrative agency and income to the Treasury.

The agency will be assigned the important task of maintaining the database of current allocation. Similar to the OET's current role at the FCC for maintaining allocation table, the agency will be charged with recording all sub-lease agreements. The database will provide the accurate information from which technical and economic analysis will be performed in interference disputes. The judicial branch will also be provided with information to base a ruling from this database. Accuracy will be imperative.

---

[183] Erica Klareich, Kenneth Arrow, Robert Aumann, John McMillan, Paul Milgrom, Roger Myerson, and Thomas Schelling. "The Bidding Game." *National Academy of the Sciences, Beyond Discovery: The Path from Research to Human Benefit*. (March 2003): 2.

A final issue is when to perform the auction for expired leases. Primary leaseholders will be able to bid to renew their lease against competition. For this reason, leaseholders may lose their operating license. The expiration auction needs to be held prior to the expiration of the lease in order to provide an adequate period for a business to execute contingency planning prior to lease expiration.

2. Advisory Duties

The role of the administrative agency in implementing this allocation scheme is not only limited to administering the leases, but to provide highly technical analysis when needed. The agency will be required to render their technical and economic opinion during the interference resolution process or as requested by the judicial system.

The agency must have the technical experience and knowledge as if it was regulating the airwaves completely. The NTIA will continue to allocate government spectrum and the FCC's role in spectrum management will dissolve. A new administrative agency will be created in order to implement the new lease-rights scheme. There will be one oversight role for the agency and that will be to protect the government spectrum bands from all interference. The spectrum used for emergency communications, navigation, and distress signals must be insured to be free from harmful interference from the commercially allocated spectrum. If harmful interference threatens a vital service within the government allocated spectrum the agency has the authority to issue an order to the harmful emitter to cease transmitting. This order should only be valid for a short period, likely twenty-four to forty-eight hours and must be validated by a judge. This is the only area where the administrative agency will possess the authority to render judgment on leaseholders. All other judgments will originate from the judicial system.

3. Dispute Resolution Process

Due to the physical nature of spectrum and the shared transmission medium, the ability to transmit effectively can be easily disrupted. A major flaw with the current FCC spectrum regulation is the apparent lack of urgency in rendering decisions. Philip Weiser

and Dale Hatfield highlighted a huge concern in their spectrum rights proposal. Any new proposal for spectrum allocation must be able to minimize the effects of harmful interference or the industry will lose confidence in the scheme and eventually lead to failure. This scheme builds upon the successful cooperation that has been exhibited in the unlicensed spectrum bands and adds a swift, three-tiered resolution process that will, "competently define and enforce [leaseholders] rights against interference."[184]

a. Three-Tiered Resolution Process

This lease-rights scheme specifies a three-step process towards interference resolution. This three-tiered resolution strategy provides an efficient system to minimize the occurrence of harmful interference. The process involves direct negotiations between leaseholders, an administrative resolution that includes technical and economic analysis, and finally litigation within the judicial system.

(1) Leaseholder Agreement. Under this lease-rights scheme, resolution of interference disputes is encouraged amongst leaseholders. Unlike the current command-and-control system of the FCC, in this system direct negotiations among the leaseholders is allowed and highly encouraged. Any mutually agreed resolutions must be reported with the administrative agency. This process ensures accurate records are kept for the purposes of administrative resolution and judicial enforcement.

(2) Administrative Proposal. Should a matter of dispute be registered with the administrative agency, the administrative body will perform a timely analysis of the dispute. The administrative proposal is meant for the purpose of a neutral observer to provide a proposed resolution based on the facts of the dispute. In order to avoid the problems associated with an extremely long wait for a bureaucratic response, the proposal must be issued by the agency in a timely manner, most likely within a few weeks.

[184] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 591.

The agency's issued proposal is not binding and must be agreed upon by all parties for adoption. As stated earlier, the administrative agency lacks enforcement authority in resolution disputes unless it is a matter of harmful interference to a vital government allocated channel.

The creation of the administrative proposal serves two purposes. It not only provides a neutral recommendation for resolution, but also an outline for the judicial system to follow should the matter become litigious.

(3) Judicial System Resolution. The final step towards resolving disputes between leaseholders is to ask a court for judgment. This final step is the same method that would be used to resolve disputes over actual land and rights associated with property. If the matter is not resolved through mutual agreement or adoption of the proposal for resolution, the judicial system will impose a ruling. As Coase wrote, "one of the purposes of the legal system is to establish the clear delimitation of rights on the basis of which transfer and recombination of rights can take place through the market."[185]

b. Efficient Resolution

Unlike the current command-and-control regulation of spectrum, this lease-rights allocation scheme provides a method for efficient resolution of disputes. It provides an answer for interference concerns that could cause loss of confidence in the scheme and it does it in a highly efficient manner. The three-tiered dispute process provides swift resolution at the lowest practical level of involvement.

Through the history of the FCC, there is an abundance of evidence that alludes to decisions being rendered based upon lobbying or political influence. In the application of property-rights in El Salvador the system allows for political pressure to impact decisions involving spectrum.[186] The lease-rights system minimizes the benefit to the lobbyists and politicians to impact the spectrum market. The administrative agency

---

[185] Ronald H. Coase. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 25.

[186] Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 443.

lacks enforcement power and the system relies upon mutual agreement among users or the legal system in rendering decisions. The role of the administrative agency is to issue a proposal based on a technical and economic analysis of the dispute. If the proposal is fair, the leaseholders can adopt the proposal as resolution. In this scheme, the government has the capability to create a lease scheme to allocate the spectrum and not manipulate it.

D. CHAPTER REVIEW

This chapter laid out the rules, rights, administrative requirements, and dispute resolution process for a lease-rights scheme. This lease scheme allows the marketplace to most efficiently allocate the available spectrum and maximizes the amount of competition in the market. The dispute resolution process is efficient and removes the unnecessary bureaucratic delays. The next chapter details how this allocation scheme improves the process and provides for more efficient allocation and promotes innovation.

THIS PAGE INTENTIONALLY LEFT BLANK

VI. CONCLUSION AND FUTURE RESEARCH

Fifty years ago, Ronald Coase changed the debate about spectrum allocation by introducing the idea of applying property-rights to spectrum allocation. Since then, proponents have almost overwhelmingly agreed that the best way to allocate spectrum would be through exclusive-use property-rights; however, the discussion about how to implement a property-rights scheme is still being argued. Although it expresses the goal of achieving a "property-rights" approach to spectrum allocation, the government has not been open to the idea of turning over spectrum rights to the commercial market. The FCC claims it is acting in the best interest of the public by maintaining possession of the airwaves since the airwaves are the property of the people of the United States. Additionally, current law forbids the ownership of the airwaves by private companies.

By leasing the airwaves, both sides of the regulation debate are satisfied. Leaseholders possess the flexibility to make use-agreements as they would with the establishment of "exclusive-use" property-rights. Yet, the government retains possession of the airwaves for the purpose of repossession of defaulted leases, redistribution of the lease, and interference protection of government allocated spectrum. The lease cycle introduces more competition into the market than a simple property-rights model. The leaseholders will compete not only with each other to make the best use of their leased band of spectrum, but also will compete against outside investors who desire to make better use of the available medium.

The administrative system established in the lease allocation scheme removes most of the bureaucratic restraints currently hindering progress in the wireless communications industry. Such an established agency would need to lack the concentration of power that the FCC currently enjoys. In the new lease-rights scheme, the Judicial System enforces decisions only after an efficient dispute resolution process that encourages cooperation amongst leaseholders. The administrative system removes the unnecessary bureaucratic restraints in allocating spectrum while establishing an efficient method to protect against interference.

The initial goals of this project were to study the current situation in spectrum allocation, research proposals for improved allocations schemes, and provide a model for a more efficient system of allocating spectrum that promotes innovation. This chapter describes the advantages of a spectrum lease-rights scheme over the current form of wireless spectrum regulation and focuses on three areas: improving physical and administrative efficiency; establishing a confident wireless communications market; and increasing the amount of competition in the marketplace. The chapter concludes with a discussion of ideas that were identified during this project for future research in improving the allocation system for the electromagnetic spectrum.

A. COMPARISON OF THE PROPOSED SCHEME VERSUS THE CURRENT REGULATION SCHEME

1. Improved Efficiency

Coase proposed that the application of market forces to the spectrum allocation problem would create the most effective tool for efficient use of the available electromagnetic spectrum. This proposed scheme aims to apply a more efficient scheme by unleashing the open-market principles and minimizing the obstacles for companies to access the available spectrum.

Efficiency in the spectrum allocation debate has two separate meanings. First, efficiency alludes to making better use of the available resource. Second, the administrative process should not introduce any unnecessary delays to the allocation process.

a. The Current System Hinders Efficient Use

The FCC maintains the same conservative approach to spectrum use that it first established with initial regulations. The same approach to treating the spectrum as an extremely scarce resource is used today. Two major problems exist in today's FCC regulation of the spectrum: it uses conservative models for interference protection and utilizes a bureaucratic oversight structure that inhibits an efficient allocation process.

Currently, the FCC aims to avoid all possibilities of interference in transmitting through the electromagnetic spectrum. This approach fails to consider the better technologies and transmission techniques that exist today and fails to make more efficient use of the spectrum. Basing spectrum decisions on "the public's interest" fails to take into consideration all aspects affected by allocation decisions made by the FCC.

The bureaucratic administrative requirements associated with the FCC make it nearly impossible to achieve more efficiency in allocating the spectrum. The current structure is not equipped to fix its own mistakes and has no incentive for the FCC to improve their performance. It takes a long time for decisions to be made by the Commission. Congress allowed too much power to be granted initially to the FCC and failed to make adequate changes in the Telecommunications Act of 1996 to improve the performance of the FCC.

b. Proposed System Promotes Efficiency

The proposed lease-rights system addresses both problems with the current form of spectrum regulation. It transfers responsibility for efficient allocation to the open market and eliminates the role of the FCC in allocating the electromagnetic spectrum.

The proposal falls short of establishing full property-rights in spectrum use, but takes advantage of all the benefits of a rights proposal by granting full flexibility to leaseholders. The innovative use of leases maintains possession of the spectrum with the government but frees the leaseholders to make secondary agreements and minimizes the restrictions on use of the leased asset. It establishes minimal restrictions in order to provide interference protection in an effective wireless communications market.

Major decisions regarding spectrum use are removed from the FCC and the government. The spacing of frequencies is not determined by an overly conservative regulator but by market forces operating under a set of fair rules. A new administrative

agency is established for oversight of the scheme, but with no enforcement power. Their role is to administer the scheme and advise in interference resolution disputes with established time requirements.

The proposed system of leasing introduces a unique form of competition into the market for spectrum. Leaseholders are granted use of the spectrum for fifteen years before it is auctioned again. This provides more incentive for the leaseholders to not only make the best use of his lease, but ensures fair market value is reevaluated periodically. This competitive process ensures the spectrum use is based on realistic technical and economic analysis. The best manner to allocate spectrum is not by an unmotivated bureaucratic agency but by the leaseholders granted flexibility to use their asset in a highly competitive market.

2. Establishing a More Confident Market

In a recent legal analysis of the property-rights allocation scheme for spectrum, Philip Weiser and Dale Hatfield present an interesting analysis of how the scheme can create a loss of confidence and failure of a property-rights allocation scheme. They contend that a property-rights system can only be effective if interference is avoided.[187] Additionally, they contend that a strictly Coasian approach would create opportunities for people to exploit the system for personal gain. Their answer to these concerns is to propose a predictive modeling system to be implemented by the FCC in order to eliminate interference.

This proposal presented by this thesis utilizes a different approach than proposed by Weiser and Hatfield. It creates a system of competitive entry and a streamlined dispute process. An administrative body provides advice in dispute resolution. Judgments are based on technical and economic analysis of the system by the judicial system. It establishes confidence by eliminating unwarranted external influence through a rapid and fair dispute resolution process.

[187] Philip J. Weiser and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 553.

a. Lack of Confidence in the Current Regulation

Throughout the existence of the FCC, numerous examples show its susceptibility to external influences from powerful lobbies and politicians. Their decision-making has not been consistent and can only be described as ad hoc.

b. Proposed Scheme Restores Confidence in Spectrum Allocation

The allocation process, through fair auctions of leases, eliminates the impact of external influence in the allocation process. The leases are available to the winning bidders who then can allocate their spectrum as they desire. The lease system encourages the leaseholders to make the most effective use of their allocated spectrum. Since there is no bureaucratic agency with power to enforce in this scheme, the political and lobby influence is minimized. Additionally, it restores the importance of the judicial system in the allocation oversight to resolve issues in interference disputes.

3. Increased Competition

In several studies, Thomas Hazlett, a former Chief Economist at the FCC, presents overwhelming evidence that the full value of the spectrum has yet to be found. Full implementation of a property-rights scheme, a stated objective of the FCC's own SPTF, has not been fully incorporated into today's policies. The FCC is shifting towards allocating more of the spectrum for unlicensed use based on flawed analysis of the economic impact of unlicensed bands.[188] "In shared bands, just providing technical and service flexibility would not create the correct incentives for economically efficient use of the spectrum, because licensees can not capture the benefits from deploying the spectrum-conserving equipment."[189] Current policies fall short of taking full advantage of a competitive market in the electromagnetic spectrum. This proposal herein allows for further advancement towards a property-rights model. It falls short of granting full

[188] Thomas W. Hazlett. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 68.

[189] Evan Kwerel and John Williams. "A Proposal for a Rapid Transition to Market Allocation of Spectrum." *Federal Communications Commission, OPP Working Paper Series* 38 (2002): 5.

property-rights to license holders, but allows for the all the economic and technical advantages of a fully implemented property-rights model.

a. Current Lack of Competition

The current form of spectrum regulation provides more competition than it ever has done but fails to take full advantage of the benefits of competitive forces in an allocation scheme. The current market has competition by attaining licenses from auction and by competition in the unlicensed bands. However, there are no performance incentives for current license-holders to make the most efficient use of their asset.

The FCC claims that unlicensed spectrum introduces competition for competing technologies in the marketplace. There is competition, but under operating parameters established by the FCC that limits the amount of competition that can actually be introduced into the marketplace. The FCC has taken some steps towards a property-based system of spectrum allocation but has failed to eliminate all unnecessary barriers induced by restrictive regulation.

b. Increased Competition in the Market

The system of allocation introduced in this proposal maximizes the amount of competition in the spectrum market. It creates a competitive market through auction of the initial lease, freedom to use their lease as desired and compete with other leaseholders in the wireless communications market, and re-evaluation of the asset every fifteen years to ensure maximum efficient use of the physical spectrum.

B. FUTURE RESEARCH

There is little doubt that the current FCC regulation of the wireless spectrum requires major changes. The spectral-lease scheme provides the opportunity to implement an allocation scheme that can keep pace with the growth of technology. For fifty years, numerous people have made proposals for improving the use of the physical spectrum through a more efficient allocation scheme. The problem remains today: the FCC is not capable of keeping up with the pace of technology and use of the spectrum is

still largely driven by regulators' decisions and not through market forces. The overall problem with the current method of implementation is that the physical resource is not being used efficiently, the result of spectrum that is not allocated effectively or efficiently.

There are several areas warranting further research in order to continue this study. The first is to look at the physical parameters of the lease scheme. The second is to take a look at improving spectrum efficiency. The third area recommended for further research by this author is the legal aspects associated with a spectrum lease allocation scheme.

1. Physical Lease Parameters

Further study needs to be done regarding the optimal assigned properties of a lease. Two questions are readily apparent: "How much spectrum is needed in order to implement current technologies?" "With the current allocation scenario, what are the ideal operating characteristics of a spectrum lease?" This scheme proposes that the leases cover the entire geographic area of the United States, the spectrum blocks be broken into equal sized 100 MHz chunks of spectrum, and that the duration of leases last fifteen years. There are technical, business, and legal aspects that can be looked into for the best method of assigning properties for each lease. In order to create an allocation scheme that promotes efficiency and innovation, the lease parameters need to be studied to determine how to best employ the lease allocation scheme.

2. Spectrum Efficiency

The electromagnetic spectrum is a finite resource. Rapidly advancing technologies and demand for wireless devices create an interesting dilemma in spectrum allocation: you cannot create more spectrum. Therefore, it is not only important that an allocation system be implemented in order to increase competition in the marketplace, but further investigation into the technologies and communication protocols is required in order to make the most efficient use of the limited spectrum available. This raises a third

question: "If in possession of a chunk of spectrum, what technologies and implementation techniques would allow for the maximum use of a fixed amount of spectrum?"

3. Legal Aspects of a Lease Allocation Scheme

This proposal establishes a new agency for allocating spectrum. The idea is to create, from scratch, an organization that implements an effective spectrum allocation scheme without hindering the process. This proposal requires administrative efforts to establish leases and rules associated with those leases, allocate the leases, and provide technical advice in the dispute resolution process. There are legal aspects to analyze in order to create an effective spectrum lease allocation scheme. "Is the current method of auction acceptable in order to allocate leases in the fairest possible manner?" "Where might possible loopholes exist for people to exploit the allocation scheme for their personal benefit and how do you close them?" "As an advisor to the Judicial Branch in highly technical manners, what set of rules would be needed to ensure the system is fair to all parties?" Weiser and Hatfield asserted that any allocation scheme needed to maintain a confident market. Efforts to liberalize other markets have failed because of vague or incomplete rules for implementation. In order to ensure a successful re-allocation of spectrum, the system must be fair and minimize the ability for personal exploitation of the market.

This right of a sovereign government to manage its spectrum resources is clear. However, its methodology for doing so must encourage the development of free market competition and the advancement of novel, emerging technologies that make the most beneficial use of that spectrum for the good of society. This thesis proposed a means for the government to maintain its ownership of its spectrum resources while ensuring the promotion of technological advancement and entrepreneurship while maintaining market confidence.

LIST OF REFERENCES

"About Auctions." *The Federal Communications Commission*. 9 August 2006. 26 January 2009 <http://wireless.fcc.gov/auctions/default.htm?job=about_auctions>.

"About ITU." *The International Telecommunications Union*. 19 March 2009. 19 March 2009 <http://www.itu.int/net/about/index.aspx>.

Abernathy, Kathleen Q. "What Tomorrow May Bring – the Future of the FCC's Licensed Spectrum Policy." Federal Communications Bar Association [Western Seminar], San Diego, CA. 20 July 2002.

Bardach, Eugene. "Why Deregulation Succeeds or Fails." *Creating Competitive Markets: The Politics of Regulatory Reform*. Ed. Marc Landy, Martin Levin, and Martin Shapiro. Washington D.C.: The Brookings Institution. 2007. 331-342.

"Broadband PCS." *The Federal Communications Commission*. 28 October 2004. 26 January 2009 <http://wireless.fcc.gov/services/index.htm?job+service_home&id=broadband_pcs>.

Coase, Ronald H. "The Federal Communications Commission." *The Journal of Law and Economics*. October 1959: 1-40. JSTOR. Naval Postgraduate School Library, Monterey, CA. 29 August 2008 <http://www.jstor.org>.

Crandall, Robert W. "Extending Deregulation: Make the U.S. Economy More Efficient." *Opportunity* '08. Washington, D.C.: The Brookings Institution, 2007.

Crandall, Robert W. and Hal J. Singer. "Telecom Time Warp." *The Brookings Institute*. 11 July 2007. 15 July 2008 < http://www.brookings.edu/opinions/2007/0711business_crandall.aspx>.

De Vany, Arthur S., Ross Eckert, Charles Meyers, and Richard Scott. "A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic-Engineering Study." *Stanford Law Review* 21.6 (1969): 1499-1561. JSTOR. Naval Postgraduate School Library, Monterey, CA. 11 September 2008 <http://www.jstor.org>.

De Vany, Arthur S. "Implementing a Market-Based Spectrum Policy." *FCC License Auctions: From Concept to Policy. A Conference on the Law and Economics of Property Rights to Radio Spectrum, 27-29 July 1996, Tomales Bay, CA.* 1996. 1-40.

"FCC Task Force Reports on Spectrum Policy Reform Progress And Initiatives." News Release. The Federal Communications Commission, Washington, D.C. 13 November 2003. FCC SPTF 2003 Headlines. 26 January 2009 <http://www.fcc.gov/sptf/headlines2003.html>.

"FCC Radio Spectrum Home Page." *The Federal Communications Commission, Office of Engineering and Technology*. 27 February 2008. 26 January 2009 <http:// www.fcc.gov/oet/spectrum/>.

The Federal Communications Commission. *Spectrum Policy Task Force Report*. ET Docket No. 02-135. November 2002. FCC SPTF Reports and Other Papers. 2 September 2008 <http://www.fcc.gov/sptf/reports.html>.

The Federal Communications Commission. *Strategic Plan 2009-2014*. 24 June 2008. FCC Strategic Plan. 26 January 2009 <http://www.fcc.gov/omd/strategicplan/>.

Fein, Michael R., and David A. Moss. "Radio Regulation Revisited: Coase, the FCC, and the Public Interest." *The Journal of Political History* 15.4 (2003): 389-416. Project Muse. 20 January 2009 <http://muse.jhu.edu/>.

Furchtgott-Roth, Harold W. *A Tough Act to Follow?*. Washington, D.C.: The American Enterprise Institute Press, 2006.

Hazlett, Thomas W. "A Law and Economics Approach to Spectrum Property Rights: A Response to Weiser and Hatfield." *George Mason Law Review* 15.4 (2008): 975-1023. Professor Thomas W. Hazlett Research Papers. 2 September 2008 <http://mason.gmu.edu/~thazlett/papers.html>.

Hazlett, Thomas W. "The Spectrum Analysis Debate: An Analysis." *IEEE Internet Computing* 10.5 (2006): 68-74. Professor Thomas W. Hazlett Research Papers. 2 September 2008 < http:// mason.gmu.edu/~thazlett/papers.html >.

Hazlett, Thomas W., Giancarlo Ibarguen, and Wayne Leighton. "Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization." *Journal of Law and Economics* 3.2 (2007): 437-84. Professor Thomas W. Hazlett Research Papers. 2 September 2008 < http:// mason.gmu.edu/~thazlett/papers.html >.

Klareich, Erica, Kenneth Arrow, Robert Aumann, John McMillan, Paul Milgrom, Roger Myerson, and Thomas Schelling. "The Bidding Game." *National Academy of the Sciences, Beyond Discovery: The Path from Research to Human Benefit*. (March 2003). 7 January 2009 <http://www.beyonddiscovery.org/content/ view.article.asp?a=3681>.

Kwerel, Evan, and John Williams. "A Proposal for a Rapid Transition to Market Allocation of Spectrum." *Federal Communications Commission, OPP Working Paper Series* 38 (2002): 1-55. Federal Communications Commission, Office of Strategic Planning and Policy Analysis. 20 October 2008 <http://www.fcc.gov/osp/workingp.html>.

Lundy, Bert. *Telegraph, Telephone and Wireless: How Telecom Changed the World*. Charleston, SC: Booksurge, 2008.

Marcus, Michael J. "Wireless Communication Standards and Regulations." Presentation at IEEE Workshop, Phoenix, AZ. 2004. 26 January 2009 <http://www.marcus-spectrum.com/ documents/Phoenix.ppt>.

Messere, Fritz. "The FCC." *Museaum of Broadcast Communications*. 8 January 2009 <http://www.museum.tv/archives/etv/F/htmlF/federalcommu/ federalcommu.htm>.

"One Year Later." Federal Communications Task Force Reports on Spectrum Policy Reform and Progress, Washington, D.C. 13 November 2003. FCC SPTF 2003 Headlines. 26 January 2009 <http://www.fcc.gov/sptf/headlines2003.html>.

"Political Favors at the FCC." Editorial. *Wall Street Journal* 10 December 2008. Wall Street Journal Online. 9 January 2009 <http://s.wsj.net/article/ SB122895503515596485.html>.

Powell, Michael K. "FCC Chairman Michael K. Powell Announces Formation of Spectrum Policy Task Force." News Release. The Federal Communications Commission, Washington, D.C. 6 June 2002.

"Secretaries." *The United States Department of Commerce*. 5 March 2009. 10 March 2009 < http://www.commerce.gov/About_Us/Secretaries/index.htm>.

Shafer, Jack. "New Wave: The Case for Killing the FCC and Selling Off Spectrum." *Slate* 17 January 2007. Slate Online. 4 August 2008 <http://www.slate.com/id/ 2157734/>.

"Third Generation Wireless Systems." *The Federal Communications Commission*. 25 November 2002. 26 January 2009 <http://www.fcc.gov/3G/>.

United States Department of Justice and the Federal Communications Commission. *Horizontal Merger Guidelines*. 8 April 1997. United States Department of Justice. 9 December 2008 <http://www.usdoj.gov/atr/public/guidelines/ hmg.htm>.

Weiser, Philip J., and Dale Hatfield. "Spectrum Policy Reform and the Next Frontier of Property Rights." *George Mason Law Review* 15.3 (2008): 549-609. LexisNexis Academic Law Reviews Searches. Naval Postgraduate School Library, Monterey, CA. 11 September 2008 <http://www.lexisnexis.com>.

"Wireless Telecommunications Bureau Agenda Meeting." The Wireless Telecommunications Bureau, The Federal Communications Commission, Washington, D.C. 20 January 2006. Archived Recordings of Commission Meetings. 26 January 2009 <http://www.fcc.gov/realaudio/agendameetings.html>.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California